# INVESTIGATIONS ON THE SALINITY PROBLEMS OF POKKALI AND KAIPAD AREAS OF KERALA STATE

BY

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DECLARATION

I hereby declare that this thesis entitled "Investigations on the salinity problems of Pokkali and Kaipad areas of Kerala State" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

3-8-77

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Vellayani,

August, 1977

## CERTIFICATE

Certified that this thesis, entitled "Investigations on the salinity problems of Pokkali and Kaipad areas of Kerala State" is a record of research work done independently by Shri. V. Samikutty, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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# C O N T E N T S

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# INTRODUCTION

Kerala with its long coastline of 580 km has sixteen lagoons or backwaters covering an area of about 650 sq.km., linked to the sea. Out of forty one rivers flowing into the Arabian sea about twenty do so by emptying their waters into the adjoining backwaters while the remaining directly join the sea. Most of the adjoining coastal land, deltaic areas at river mouths and reclaimed backwaters are either at sea level or 1 to 1½ meters below sea level. This leads to the intrusion or incursion of saline water either directly from the sea, through the backwaters or through the river mouths upto a distance 10 to 20 km upstream during high tides. Thus the saline water intruded lands constitute the major saline soil areas of the State. The problems of management posed by these soils are entirely different from that of the more extensive and much studied saline soils encountered in the irrigated plains of North India. Similar coastal saline soils, but formed from an entirely different agro-climatic situations also exists extensively.

Bhumbla (1977) has recognised three major types of coastal saline soils in India.

| | | | | |
|---|---|---|---|---|
| 1. | Coastal saline soils of arid areas | - 0.714 | million | hectares |
| 2. | Deltaic coastal saline soils of humid areas | - 1.394 | ,, | ,, |
| 3. | Acid saline soils | - 0.016 | ,, | ,, |

# INTRODUCTION

About 39,000 hectares of saline soils of Kerala come under the last two categories.

Based on the locations and salinity four types of saline lands can be recognised in Kerala. The Pokkali lands of the Ernakulam district known after the "Pokkali type" of cultivation and the Orumundakan lands (Oru-means saline) of the Alleppey and Quilon districts known after the long duration variety grown in them are saline due to incursion of sea water through lagoons. The Kaipad lands of the Cannanore district are situated in the low lying deltaic areas of river and riverlet mouths. The Kayal lands (reclaimed lake-beds) have been reclaimed from the backwaters by the construction of semi-submersible bunds. The Kayal lands have been reclaimed from the Vembanad lake and the Kayamkulam lake and comprise an area of 8000 to 9000 hectares. The former three types together comprise an area of 30,000 hectares.

One of the reclamation approaches made in the last few years is to find an engineering solution by the construction of salt water barriers. In atleast three locations this has been attempted in Kerala. They are the Kattampally salt water barrier which prevents the incursion of salt water into the Kattampally river and adjoining Kaipad lands. Another is salt water barrier at Enamakkal in Trichur which prevents the salt water intrusion into the Kole lands of Trichur and the third is Thanneermukkom-Vechur salt water barrier which prevents the entry of salt water into the entire Kuttanad basin.

Fairly detailed studies on seasonal variation in salinity in the soils of Kuttanad prior to the completion of Vechur-Thanneermukkom bund, the physical, chemical and physico-chemical properties of the soils of the Kuttanad region and the Kole have been made by Kurup (1967), Aiyer and Kurup (1973), Aiyer and Money (1959), Gangadhara Menon (1975), Hameed (1975) etc. However fundamental studies on the major saline areas represented by the Kaipad, Pokkali and Orumundakan have not been attempted except for a preliminary report on the Pokkali soils by Varghese (1970).

The Pokkali, Kaipad and Orumundakan areas are cropped to one crop of paddy taken during the months of June-July to October-November, the periods of high monsoon rainfall. Indigeneous cultural methods coupled with local saline resistant rice varieties make possible the cultivation of these areas, but the production is deplorably low. In the Kaipad and Pokkali areas the cultivation is done by taking mounds of approximately 1 metre diameter, 1/4 to 3/4 metre high and spaced 60 to 70 cm apart, edge to edge. The sprouted saline resistant seeds are sown in the mounds when the salinity in them has been brought down sufficiently by the washing effected by the pre-monsoon and early monsoon rains. In the "Pokkali type" cultivation sprouted seeds are sown on the mounds. After 30 to 35 days the mounds are dismantled along with the seedlings and distributed throughout the field. Alternatively in some locations, especially in the Kaipad areas, saline resistant seedlings are raised in non-saline nurseries and transplanted on the mounds in the months of June-July. In some locations especially in Puthuvaippu, Cherai etc. instead of mounds, long raised beds are taken and seeds sown or transplanted on these beds when the salinity levels have been brought down by the monsoon rains. The common varieties grown are Cheruviruppu, Choottu pokkali, Chettiviruppu and Kuthiru which are of 120-135 days duration. In the Orumundakan areas the Orumundakan variety with a duration of 270 days is generally grown. 90 day old seedlings raised in non-saline fields are transplanted in the month of August-September in the prepared Orumundakan fields which by this time would have got their salinity levels lowered by the leaching action of the rains.

After the harvest of the paddy crop the sluices in the outer bunds are opened and sea water or brackish water is allowed to enter the fields. In the Kaipad and Pokkali areas prawn culture is resorted to during the period of submergence. Since very little information is available regarding the properties of these saline soils the present investigation was undertaken with the following main objectives.

1. To study the profile characteristics of the three major types of saline soils viz., the Kaipad, Pokkali and Orumundakan.
2. To examine the extent of salinity in a large number of surface samples of the three areas to define maximum salinity hazards.

3. To study the seasonal variation in salinity, pH, cationic and anionic characteristics of the saturation extracts of these soils at fortnightly intervals from the three selected locations representing the three soil types.
4. To assess critically the beneficial effects of the present mound system of cultivation in the *Kaipad* and *Pokkali* areas.
5. To study the seasonal variation in salinity levels of the surface waters from these three locations.

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

Soil salinity is one of the major problems in some of the cultivated soils of Kerala. This problem is mainly prevalent in coastal areas subjected to sea water intrusion and areas which are flooded by the backwaters. The soil salinity has also been aggravated by the indiscriminate use of saline irrigation water. Detailed studies of these areas in Kerala have not been made and the following review of literature presents information on similar and related soils.

## A. PHYSICAL, CHEMICAL AND NUTRIENT STATUS

### Physical

Sen and Deb (1941) reported that volume expansion and specific gravities bear no relation to clay content of soils. Joachim and Kandiah (1947) found a high correlation between clay content and water holding capacity.

Dhanapalan Mosi (1960) studying the profile characteristics of red soils of South India found an increase in clay content with increase in profile depth, the values being 28.5 per cent and 44.9 per cent for the top and third horizons respectively. In some profiles the clay content increased progressively from 19.9 per cent in the top to 33.9 per cent in the third horizon.

Varghese *et al.* (1970) in a preliminary study of the Pokkali soils of Kerala found that the clay and silt content increases with profile depth whereas the sand fraction decreases with profile depth.

Koshy and Varghese (1971) observed that the Peaty or Kari soils are characterised by a deep black colour, heavy texture, poor drainage, extremely high content of organic matter and strong acidity.

Velayudham and Raj (1971) established that the influence of clay was more than that of organic carbon on the water holding capacity.

Ghosh *et al.* (1973) reported that bulk density and particle density of Kari soils of Kerala varied from 1.24 to 1.46 and 2.52 to 2.56 gm/cc respectively.

Gangadhara Menon (1975) observed that the bulk density and particle density of the Kuttanad soils of Kerala ranged from 0.90 to 1.30 and 1.90 to 2.31 gm/cc respectively.

Coultas and Calhoun (1976) studied the tidal marsh soils of Florida and observed that the bulk density of the organic soil layers ranged from 0.13 to 0.36 gm/cm$^3$ whereas that of the clayey layers ranged between 0.16 and 0.26 gm/cm$^3$.

**Chemical**

Moormann (1962) concluded that the acid soils with considerable high content of sulphate showed extreme variability in soil reaction. pH gradually increased to neutral point on inundation and decreased rapidly to extreme acid range on drying.

Harn *et al.* (1967) reported that in poorly drained clay soils, affected by salt water intrusion, electrical conductivity of the saturation extract could be as high as 50 mmhos/cm.

Nair and Money (1972) found that some of the salt affected soils of Kerala showed high conductivity (1:2) ranging from 4.2 to 14 mmhos/cm. Eventhough the conductivity is high the soil is found to be acidic and the pH values ranged from 3 to 6.8. They also reported high negative correlation between pH and $SO_4$ content.

Segeren and Smits (1974) reported that acid sulphate soils occurring along the sea coasts of Kerala are extremely acidic because of the excess amount of sulphur and lack of $CaCO_3$ in these soils. Coultas and Gross (1975) studied the three great soil groups in the tidal marshes of Florida's gulf coast and found that the EC values range from 14 to 90 mmhos/cm and field moist pH range between 5.6 and 7.8 and air dried pH values 2 to 3 pH units lower.

Nutrients

Organic carbon and C/N ratio.

Sukumara Pillai (1964) investigated the properties of Kari soils of Kerala and found that they are rich in organic matter and low in major nutrients.

Maliwal (1969) studied 110 soil samples of saline water irrigated areas of Rajastan and observed them to be low in fertility status. He observed the organic matter content range from 0.24 to 2.63 per cent.

Koshy (1970) reported that C/N ratio ranged from 12.17 in a submerged rice soil to 23.67 in a Kari soil.

Ghosh et al.(1973) and Aiyer and Money (1959) found a high percentage of organic carbon in Thottapally Kari and Kattampally Swamp soils.

Coultas and Calhoun (1976) investigated the properties of some tidal marsh soils of Florida and reported that the Psammaquents contained high level of organic matter (7.8 per-cent to 28.9 per cent organic carbon).

Nitrogen.

Nambiar (1960) in his studies on the effect of liming on laterite soils of west coast found that liming favoured minera-lisation of soil nitrogen.

Elovskaya (1967) observed that the saline soils of Yakutia have a humus horizon 10 to 30 cm thick containing 0.2 to 0.5 per cent nitrogen and 0.13 to 0.23 per cent phosphorus. Varghese et al.(1970) found that the Pokkali soils of Kerala varies in total nitrogen content from 0.037 to 0.063 per cent and also noted an increase in trend with profile depth.

Nitant (1974) reported that both high pH and salinity reduced nitrogen mineralisation to a great extent.

Gandhi and Paliwal (1976) made extensive incubation studies upto six weeks on the mineralisation of nitrogen and found that mineralisation of nitrogen decreases with increase in salinity and mineralisation of nitrogen varies with the soil type. Sanghi et al.(1976) examined 2709 saline soil samples of Jodphur division and observed that N, P and K was low in 89, 26 and 21 per cent respectively.

Phosphorus.

Koshy and Britomutunayagam (1961 and 1965) in their study on Kerala soil profiles found the level of total soil phosphorus ranging from 0.024 to 0.0256 per cent. However they had not included the saline soils of Kerala in their study.

Kurup (1967) reported that the phosphorus availability is substantially increased in limed than in unlimed samples of Kuttanad soils.

Holmen (1968) noted that Peat soils are often deficient in phosphorus and potassium and sometimes nitrogen.

Varghese et al.(1970) observed that the Pokkali soils of Kerala are highly deficient in phosphorus ($P_2O_5$ content varied from 0.009 to 0.049 per cent).

Nair and Money (1972) observed that the phosphorus content of some of the saline soils of Kerala, ranged from 0.038 to 0.166 per cent $P_2O_5$.

Ghosh et al.(1973) and Venugopal (1969) in their studies on Kari soils of Kerala reported low phosphorus content.

Potassium.

Scheffer et al.(1960) studied the potassium economy and mineral status of the Gottingen soils and found that the total potassium content was 1.78 to 1.94 per cent. Varghese et al. (1970) examined the Pokkali soils of Kerala and observed that the $K_2O$ content ranges from 0.224 to 0.842 per cent.

Nair and Money (1972) found that the $K_2O$ content of some of the saline soils of Kerala varied from 0.087 to 0.286 per cent. Sreedevi and Aiyer (1973) reported that the Kari soils showed highest amount of K fixation and the Kole soils showed the least. They also found that the paddy soils of Kerala are fairly rich in total potassium content.

Cation exchange capacity.

Gopalaswamy (1961) reported a high C.E.C. for Kari soils of Kerala which was attributed to high content of organic matter and illitic and montmorillonite types of clay minerals present in them.

Sreedevi and Aiyer (1973) in their studies on the potassium status of rice soils of Kerala found that the Kari soils had the highest CEC and the content of exchangeable K was fairly high.

Menon and Aiyer (1975) reported that the mildly saline soils viz. the Kayal soils of Kuttanad, the CEC ranged from 9.92 to 19.30 me/100 g.

Coultas and Gross (1975) in their study on the three great soil groups in the Florida's gulf coast found that the CEC ranges from 2 to 25 me/100 g for Psammaquents and Haplaquods and from 25 to 75 me/100 g for sulphaquents.

B. SALINIZATION ASPECTS

Buringh (1965) concluded that the main factors of soil salinisation in Mesopotamia are a meso relief as a result of light textured irrigation sediments and extensive fallowing.

Elgabaly and Naguib (1965) through a lysimeter study established that at high salinity the depth of ground water is the more important contributing factor to the soil salinity in the surface layers. According to them depth and salinity of groundwater have little effect on the salinity of sub-soil, which is more affected by cropping and irrigation regime.

Gasenkovi and Kalacheve (1965) reported that analysis of the aqueous extracts of the soils collected can be simplified by omitting determination of cations and restricting determination of anions mainly to chloride.

Tyulpanou *et al.* (1965) studied the change in physico-chemical characteristics of the solonets-solonchak soils formed on eluvia of tertiary deposits and reported that the content of water soluble salts was 0.296 to 0.496 per cent with chlorides predominating over sulphate and the exchangeable sodium ranged from 16.8 to 30 per cent of the sum of the exchangeable bases.

Fattakh (1966) observed that capillary rise of chloride was quicker and greater than that of sulphate.

Handa (1966) noticed that due to the presence of varying amounts of $SiO_2$ in ground water total dissolved salts and total soluble cations did not always increase with electrical conductivity. Servant and Servat (1966) reported that analytical methods based on soil saturation extracts are considered best to the study of soil salinization caused by saline water table or periodic flooding by sea water and some criteria used in the classification of saline soils are based on the data obtained from soil saturation extract.

Shopski (1966) investigated salinisation and de-salinisation of soil and ground water in the Karavoas low land, is of the opinion that salinisation occurred mainly in the period when water table was close to the surface (0.4 to 1 m) and rainfall and air temperatures have not affected salinisation.

Slovskaya (1967) observed that the saline soils of Yakutia are mostly crysogenic-meadow chernosems and the salinity is mainly of the $SO_4$-cl type.

Seth (1967) established four salinity groups based on the conductivity range; less than 1-normal, 1 to 2-becoming saline, 2 to 3-saline, above 3-highly saline.

Sokolovskii (1967) studied the saline soils of Cuba and their reclamation. According to him the saline soils of the country divided into inland and coastal soils and the inland soils have been formed without any direct connection with the sea water and have lower chloride content than the coastal soils.

Williams (1968) reported that the dominant salinity controls were soil texture, permeability and topography, all which were related to depositional history and rainfall and evaporation had only a minor influence on salt distribution.

Durand (1969) studied the formation and classification of saline soils in the Senegal delta. He reported that the salt content in the soil originates from sea water and the area is subjected to annual floods and acid sulphate soils are the most common type.

Avenimelech and Men (1970) suggested that the dilution of the soil solution during the preparation of the saturated soil paste must be taken into account and they proposed a correction for the evaluation of salinity effects on the basis of EC of the saturation extract.

Rajasubramanian et al. (1970) observed an increase in ESP and a decrease in the exchangeable Ca + Mg with increase in SAR and concentration of salt solution. They further observed that the correlation between the amount of K in equilibrium solution and those of the exchange complex of the soil after equilibriation were highly significant.

Randall (1970) reported that the amount of salt in the soil on the coast of Barbados was controlled strongly by clay content and distance from the sea. He observed a positive relationship between soil salt and clay and an inverse relationship between soil salt and distance.

Varghese et al. (1970) stated that the Pokkali soils of Kerala are acidic throughout and have a high EC due to the intrusion of salt water from the adjoining lakes.

Federou et al. (1971) investigated the solonchaks of the marine zone of the Terek delta and observed that there are two types of solonchaks hydromorphic and residual. The first type undergoing progressive chloride salinisation and its highly mineralised ground water is near the surface and the second had chloride-sulphate salinity and its ground water is below a critical level.

Frankart and Herbillon (1971) reported that in the halomorphic soils of the lower Rusisi (Burundi), sodium is the dominant cation in the younger soils and magnesium in the older soils.

Konstantinov (1971) stated that the mechanical composition sometimes alters down the profile and the maximum salt content in the soil occurs where there is a sharp textural contrast.

Takhtamyshev (1971) reported that large amounts of $MgSO_4$, $CaSO_4$ and $Na_2SO_4$ occur in the top horizons of bottom land soils of the river Zeravshan and $SO_4$ represents 80 to 90 per cent of salts in the soil.

Pawluk (1973) reported the relationship of ground water table to the formation of solonetzic soils in Alberta, Canada. Ground water table within less than approximately 1 meter of the surface may result in strong surface salinization, while water table between 1.3 to 2 meter may result salinization of the top one meter. Extent of salinization sharply decreases with water table below 2 meter depth. In areas with fluctuating water table salt may spread throughout the profile.

Sharma and Primar (1973) reported that the effect of ground water salinities was more pronounced with a shallower water table than with a deeper water table.

Allbrook (1974) studied the chronosequence of soils derived from marine sediments in West Malaysia. The EC, extractable Na, exchangeable Ca, Mg, pH and total Mn decreased with increasing distance from the coast and increased with depth in soils derived from recent marine deposits. No pattern of change either with increasing depth or increasing distance from the coast was recognised in CEC, clay mineralogy, or particle size distribution.

Darab (1974) reported that the accuracy of determination of soil salinity was influenced by error of sampling due to uneven vertical and horizontal distribution of water soluble and exchangeable sodium compounds.

Elsokkary *et al.*(1974) investigated the effect of sea water intrusion on the soil salinity status of the Saunania project in the northern coastal area of Egypt. They have studied 18 profiles at various distances from the coast, the salt content in the ground water decreased from north to south. The values for EC, Cl and SAR were higher in soils near the coast than in the sea water and decreased from north to south. Generally in both soil and ground water Na and Cl were the predominant ions.

Liebhart and Shortall (1974) stated that potassium is responsible for salinity in soils amended with poultry manure and they established that application of poultry manure increased the salinity of sandy coastal plain soils.

Segeren and Smits (1974) reported that acid sulphate soils occurring along the sea coasts of Kerala are extremely acidic because of the excess amount of sulphur and lack of $CaCO_3$ in these soils. The soils exhibit very low pH values and does not permit plant growth.

Coover *et al.*(1975) studied the application of soil taxonomy in tidal areas of southern United States. Several million hectares of soil in the country are subject to inundation by tidal action and the influence of sea water is reflected in the higher proportions of Na and Mg in these soils and organic matter have accumulated over extensive areas. Addition to soil taxonomy are proposed for further testing, including sub groups of hydraquents and sulphaquents and halic great groups of Alfisols, Entisols and Histosols.

Coultas and Gross (1975) reported that three great soil groups were found in the tidal marshes of Florida's gulf coast. These were sulphaquents, psammaquents and haploquods. The sulphaquents observed at lower elevations while the psammaquents and haploquods were found at higher elevation adjoining uplands. These soils are saline and near neutral in pH. Three pedons representative of the major soils were described and sampled. The content of sulphur is less than 0.75 per cent in the psammaquents and haploquods to 6.8 per cent in the sulphaquents and most soils are nearly base saturated.

Banerjee <u>et al.</u> (1976) investigated the salinity problem of pond soils in the deltaic region of Lower Sunderbans. The initial soil salinity has been found to be 49.1 mmhos/cm (average) and the initial water salinity of the R type ponds has been noted to be 22.5 mmhos/cm.

Coultas and Calhoun (1976) studied the properties of some tidal marsh soils of Florida. They observed psammaquents, sulfihemists and sulfaquents in the tidal marshes of Hernado (gulf coast) and Duval (atlantic coast) counties. These soils were saline and nearly neutral in pH and with the exception of psammaquents, contains higher levels of sulphur (2.66 to 5.19 per cent).

Subramanian *et al.* (1976) studied the nature and extent of salinisation of the coastal tract of Tamluk sub-division of Midnapore (W. Bengal). The study revealed that the soils of which the salinity ($EC_e$) ranged between 1.8 and 52.4 mmhos/cm were in general degraded saline-alkali soils. Most of the river and tank water samples collected randomly from the area exhibited high salinity. The intensity of salinity as characterised by EC, SAR and concentration of chloride and sodiumchloride of the surface soil and ground waters, in general, increased with decreasing distance from the rivers and sea coast.

Bhargava (1977) described other coastal soils. He observed that a shallow saline water table exists in these soils and always remain within 1 meter depth. The surface horizon 16 cm thick contains 3.93 per cent salt (computed), water soluble salts nearly all chlorides and sulphates. The soil is characterised to have a salic horizon and the ESP values though less than 15 remain nearly uniform throughout the depth.

C. THE MODERN APPROACHES IN THE CLASSIFICATION OF SALINE AND SODIC SOILS

(1) Russian approach

Pak (1971), based primarily on the genetic profile concept, the solonets soils commonly occurring within the chernozem, chestnut, brown semi-desert and brown meadow soils have been grouped into nine major types in the U.S.S.R. Driessen (1970) differentiated solonchaks considering the nature of electrolytes present and using the anionic quotients, grouping into sub-classes like chloride, nitrate, sulphate etc. The criteria of ionic specificity as per their physical as well as physiological role resulted in the formation of non-uniform limits of salt content for different ionic types, to fall within the same salinity class. Solonetz on the other hand present similarity, based on which Kovda (1973) described a typical solonetz profile to comprise of an eluvial A horizon lying over an illuvial columnar to prismatic or blocky B1 horizon, followed by a carbonate B2 horizon and finally the salt horizon.

(2) American approach

According to Driessen (1970) the American approach basically differs from the Russian in being non-specific about the nature of electrolytes present. The two systems further differ in the limits of salt content for salinity class determination. With the release of the comprehensive system of soil classification (USDA, 1960, 1970) significant changes in the system of soil classification have taken place. Though the system has been criticised for being extra profile in nature (Gerasimov, 1969); leading to inconsistency or absurdity (Webster, 1968); it is widely in use and being tested on a large number of soils grouping the soils under ten orders, the system makes use of six diagnostic surface horizons, viz., ochric, mollic, umbric, histic, anthropic and plaggen; an equal number of subsurface diagnostic horizons viz., argillic, natric, agric, cambic, spodic and oxic along with three additional horizons viz., calcic, gypsic and salic and two hard pans viz., duripan and fragipan. The system envisages to classify soils making use of measurable soils characteristics. As such the saline-alkali soils find place in the salorthids, natrargids, halaquepts, natrustalfs, natraqualfs, natraquolls or natrustolls great groups within the system.

(3) F.A.O. system of soil classification

The F.A.O. system of soil classification is not more than a selective combination of a few genetic elements in a much formalised form (Gerasimov, 1969). Similar to American system this makes use of four types of A horizons viz., melanic (humus with base saturation less than 50 per cent), sombric (saturation greater than 50 per cent) histic (coarse humus with 20 to 30 per cent organic material) and pallid (poorly developed); five types of B horizons viz., argilluvic; natric; cambic, spodic, and oxic and five additional types of horizons viz., calcic, gypsic, salic, plinthic and gleyic; Obviously the natric and salic horizons of the American system have been incorporated to describe the conditions of alkalinity or salinity. But unlike "Soil Taxonomy" it provides a separate unit for solonchaks while other soils not so distinctly saline or alkali in nature find place under the broad soil unit of "Halosols" with sub units of Ochric solonetz, humic solonetz, gleyic solonetz, ochric solonchaks and humic solonchaks.

Some of the solonetz met within the United States closely resemble the typical Russian solonetz, typical profile of which has been described by Kovda (1973). The provision within the "Soil Taxonomy" that soluble salts if present occur in or below the natric horizon bring the two solonets still closer. However, the generalised form of F.A.O. system is obvious from the definition of the sodic phase which stipulates more than 6 per cent saturation with exchangeable sodium in some horizons within 100 cm of the surface. The natric phase, however, at the same time excludes solonets soils because their B horizons have a high exchangeable sodium saturation. Similarly, the solonchaks have been defined to have atleast 2 per cent easily soluble salts in the upper-most soil horizons (30 cm) (FAO, 1974).

(4) Hungarian approach

Abraham and Bocskai (1971) described the typical solonets soils occurring in Hungary and are grouped as solonchak, solonets, meadow solonets, meadow solonets turning into steppe solonised meadow and solod types and the meadow solonets are the most abundant. The central character of these soils is similar to the Russian solonets. Chemical characteristics of soils presented by Darab (1971) reveal a fair degree of overlap within the meadow solonets, meadow solonets turning into steppe and solonetsic meadow soils.

(5) Attempts at classification made in India

Govinda Rajan (1970) prepared soil map of India comprising of 25 broad soil units, established primarily on genetic profile concept. The saline-alkali soils which constitute one separate unit in the legend were not separately depicted in this map.

Abrol and Bhumbla (1971) however, grouped the saline-alkali soils of India based on their geographical distribution into the following broad categories.

(i) Soils occurring in the arid alluvial tracts of Punjab, Haryana and Rajasthan

(ii) Soils occurring in the semi-arid regions of Utter Pradesh, Haryana and Punjab

(iii) Soils in the arid and semi-arid tracts of Deccan consisting principally of irrigated deep black soils or "regurs" and

(iv) Saline soils occurring along the sea coast.

Raychaudhuri (1973) described the existing problem of soil salinity and alkalinity in the country comprising that of three unique situations viz., saline soils, highly alkali-saline soils and slightly alkali-saline soils. Bhumbla (1975) presented the nature as well as spatial distribution of the problem by depicting six different types of problematic soils viz., alkali, saline, potentially saline, coastal saline, deltaic saline and the saline acid sulphate soils occurring within the country.

Kanwar and Sehgal (1962); Raychaudhuri et al.(1962); Kanwar and Bhumbla (1969); Bhargava et al.(1972); Bhumbla et al. (1973); Sehgal et al.(1975) and others have studied the characteristics of salino-alkali soils mentioned above. But the main features which emerges are the lack of well defined soil classification system developed within the country especially for grouping saline-alkali soils and Abrol (1971) and Bhumbla (1975) have successfully defined the nature of problems prevailing in the country and also illustrated their geographic distribution. Bhargava (1977) made an attempt to characterise and classify some of the coastal saline soils of Andhra Pradesh following "Soil Taxonomy". He grouped a profile described from Chirala Tehsil of Ongole district of Andra Pradesh as belonging to natric salfluvaquents.

D. SEASONAL VARIATION IN SALINITY

The seasonal fluctuations in salinity have been studied by many workers. Magistad et al.(1943) reported that salinity effects are more drastic under hot dry conditions than under cooler, humid ones.

Molfino (1945) examined pH variations in flax soils over a period of seven years concluded that high temperature and low rainfall were conducive for alkalinity while the reverse conditions for acidity, thus establishing a correlation between climatic variations and pH changes.

Tomlinson (1957) from his monthly determination of pH of some rice soils of Sierra Leone for a period of thirty two months, suggested that the increase of pH value during wet season and decrease during dry season were the result of translocation of water soluble acidic compounds to and from the soil surface.

Bowser and Leat (1958) observed the variations of pH from neutral to strong acidity were related to changes in soil moisture probably due to microbial activity.

Yu *et al.* (1959) working in the acid and neutral soils of Central China found that the conductivity of the ploughed layer was by and large, was closely related with soil fertility. Conductivity of different soil samples become less conspicuous during plant growth, suggesting the adsorption of nutrient ions by the roots. This was also indicated by the low conductivity of the rhizosphere compared with the bulk of the sample.

Moormann (1962) observed that the pH values in acid sulphate soils were extremely variable. Seasonal variations of pH were very pronounced, especially in periodically inundated lands, such as rice fields. During inundation pH values increased gradually, eventually coming close to neutral, whereas during the following dry period they dropped quickly.

Susheela Devi (1965) found that the seasonal variations in pH are very pronounced especially in periodically inundated lands like rice fields.

Bandyopadhya *et al.* (1970) studying the seasonal fluctuations of salinity in rice soils, determined pH, EC, exchangeable Na, Ca and Mg. They observed marked seasonal fluctuations in association with rise and fall of ground water table.

Graveland (1970) studied the migration of soluble salts in an irrigated field in relation to rainfall and irrigation. He estimated the pH, EC, Ca + Mg, Na and moisture retention during the growth season at five different depths and observed that the soluble salt content varied by upto 100 per cent or more and were inversely related to soil moisture levels.

Gupta and Abichandani (1970) studied the seasonal variation in the salt composition of some saline water irrigated zones of western Rajastan. After rains amounting to 35 to 45 cm, initial high salt concentration in the soil was greatly reduced making the surface 40 cm completely non-saline. The surface soil of Na-Mg-Cl-$SO_4$ type before rainfall became Na-Ca-Cl $HCO_3$ type after rainfall.

Kurup and Aiyer (1973) from a study on seasonal variation reported that for all the three major types of Kuttanad soils viz., Kari, Kayal and Karapadom the maximum and minimum values for soil pH and minimum and maximum values for electrical conductivity, were during the periods of October-November and March-April respectively.

Arjan Singh and Singh (1974) examined seasonal changes in the salt content of an irrigated sandy soil under maize-wheat rotation. Water table depth in the area fluctuated and within 150 cm from the surface during monsoon. Salt accumulation at and near the soil surface was at maximum during the hotter days of summer, but returned to the previous level after the end of the monsoon season. Monsoon rain thus appears to be very effective in checking salt build up in the surface soil.

Banerjee et al.(1976) studied the salinity problem of pond soils in the deltaic region of Lower Sunderbans and concluded that the soil and water salinity decreased gradually with the addition of more rain water.

E. RECLAMATION AND MANAGEMENT

Pekatoros (1953) observed that deep ploughing to 35 cm accompanied by small application of gypsum and green manure improved the solonetz like soils of the left bank of the Lower Dnieper and increased the cotton yield.

Krishna Rao and Raja Rao (1960) reported that addition of molasses produced consistently high yields of paddy in the coastal saline sandy soil in Andra Pradesh.

Cairns (1961) considered deep ploughing a promising ameliorative method for a solonetsic soil.

Leaching studies reported by Hulsbos (1963) show that leaching efficiency differs in different soils depending upon their pore space distribution. He found higher leaching efficiency in the light textured soil than in the clayey soil.

Zende et al.(1963) reported that the application of waste products like groundnut hulls, safflower hulls and tamarind seeds reduced salinity status.

El.Abedine (1965) reported that cultivation following reclamation by drainage and irrigation reduced salt content of the surface soil, the conductivity of the 1:20 soil extract lowered from 8.19 to 0.58 mmhos.

Agarwal and Gupta (1968) observed that four years of leaching brought about decrease in salinity, pH and ESP values of the surface soil and an increase in crop yields.

Balba and Ellaithy (1968) found addition of $CaSO_4$ enhanced the efficiency of leaching process of a saline-alkali soil.

Patnaik and Bandyopadhya (1968) reported that industrial waste products (basic slag and lime sludge) and calcareous and iron rich mineral soil were effective substitute for gypsum under conditions were NaCl was the predominant salt.

Sahota and Bhumbla (1970) stated that alternate flooding and drying was more effective than continuous ponding in the removal of excess salts in the saline-alkali soils.

Misra and Khan (1971) reported that iron sulphate, aluminium sulphate and sulphur were most effective for reclaiming saline sodic soils under waterlogged conditions and they also observed that application of high rates of spartin were also beneficial.

Patnaik and Sahoo (1971) studied the coastal saline soils and found that addition of industrial waste products like basic slag and paper mill sludge resulted in more effective leaching of soluble salts by improving the physical condition and these material could act as an efficient amendment as gypsum.

Iyer and Narayanan (1972) formulated drainage measures adopted for the reclamation of the saline soils in Kole and Kuttanad areas of Kerala State. (1) construction of permanent non-submersible bunds in the farm lands (2) improvement to the existing drainage courses to ensure effective drainage (3) provision of good quality irrigation water.

Bandyopadhya et al.(1976) initiated some studies to implement the objectives (1) drainage of as much rain water as possible into the sea during the early monsoon (2) storage of as much rain water as possible inland during the receding part of monsoon, in an operation size area at Gosaba (W. Bengal). Their work consisted of improving the existing drainage channel, construction of field bunds in the upper catchment, storing rain water in the latter half of monsoon in drainage channels and re-utilising it for irrigation.

# MATERIALS AND METHODS

# MATERIALS AND METHODS

The soils used in this investigation were collected from three distinct saline soil areas of the State viz., Pokkali, Kaipad and Orumundakan. Based on a reconnaissance of the areas, six profiles were selected for the study, three from Pokkali lands of Ernakulam district, two from Kaipad areas of Cannanore district and one from Orumundakan fields of Quilon district. The profiles were dug and samples collected in the months of February and March when there were no crops in the fields and the salinity hazard was a maximum. The profiles were examined for morphological features according to the FAO system. The morphological and other characteristics of these profiles were presented in tables 1 to 6. In order to know the extent of salinity hazards in these three major saline soil zones of the State, thirty four surface samples were also collected. Periodical collection of surface soil and surface water samples were made at fortnightly intervals from marked localities of these three regions to study the seasonal variation in salinity and the factors controlling the same.

## LABORATORY STUDIES

### A. 1. Preparation of sample for analysis

The samples collected were air dried on a sheet of paper and were ground separately using a clean porcelain mortar and a wooden pestle, sieved through a 2 mm sieve and stored in stoppered bottles for subsequent analysis.

2. Determination of physical properties

(a) Mechanical analysis.

The mechanical composition of the profile samples were determined by the international pipette method (Piper, 1950).

(b) Single value constants.

The bulk density, particle density, maximum water holding capacity, pore space and volume expansion were determined by the Keen-Raczkowski-box method (Piper, 1950).

(c) Moisture

A known weight of the soil was taken in a silica dish and dried in an air oven at 105°C to constant weight. The difference in weight was noted and expressed as percentage on oven dry basis (A.O.A.C., 1962).

3. Determination of chemical constituents

(a) Soil reaction.

The pH of the soil samples were measured in a 1:2.5 soil-water suspension using the glass electrode of a photo volt pH meter.

(b) Electrical conductivity.

The electrical conductivity of the soil samples were measured in a 1:2 soil-water suspension using the solubridge-U.S. salinity laboratory type and the results were expressed in millimhos/cm.

(c) Organic carbon.

Organic carbon was determined by Walkley and Black's rapid titration method as given by Piper, 1950.

(d) Total nitrogen

Total nitrogen was estimated by Kjeldahl method using sulphuric acid salicilic acid mixture (Jackson, 1967).

(e) Analysis of Hydrochloric acid extract.

Preparation of the extract

20 g of soil was used for the preparation of the HCl extract using the method described by Piper, 1950.

(i) Total phosphorus

20 ml of the HCl extract was used for the precipitation of phosphorus as ammonium phosphomolybdate in nitric acid medium. The precipitate was filtered, washed free of acid and dissolved in a known excess of standard sodium hydroxide and the excess determined by titration with standard acid.

(ii) Total calcium and magnesium

20 ml of the HCl extract was used for this purpose. The iron and aluminium were removed by precipitation as hydroxide in ammoniacal medium and the filtrate was made upto 100 ml. A 10 ml aliquot of the filtrate was used for the estimation of calcium and magnesium by Versenate titration method (U.S.D.A. Hand Book No.60, 1954).

(iii) Total potassium and sodium

Total potassium and sodium were determined in a sample of the extract using EEL flame photometer (Jackson, 1967).

(iv) Sesquioxides

The combined hydroxides of iron and aluminium obtained under item 3 e (ii) was dried, ignited, weighed and expressed as percentage sesquioxide.

(v) Iron oxide

Iron was estimated in a sample of the extract by reducing it to ferrous form with nascent hydrogen obtained from zinc and sulphuric acid and titrating it against decinormal potassium permanganate (A.O.A.C., 1962).

(vi) Aluminium oxide

The aluminium oxide present in the soil was calculated by substracting the value of independently estimated iron oxide from the total sesquioxide value (A.O.A.C., 1962).

4. Cation exchange capacity and exchangeable cations

(a) Cation exchange capacity.

A known quantity of the soil was first treated with 40 per cent ethanol (100 ml) to remove soluble salts. The washing was repeated twice, each time using 100 ml of ethanol to ensure complete removal of soluble salts. The washed soil was treated with neutral normal ammonium acetate to displace all the cations by ammonium ions. The excess ammonium acetate was removed by washing with alcohol. The adsorbed ammonium was then determined by absorption in standard acid after displacing it by the addition of magnesium oxide followed by steam distillation. The distillate was titrated against standard hydrochloric acid using bromocresol green indicator and CEC calculated and reported as me/100 g soil (Hanna, 1964).

(b) Exchangeable cations.

The leachate obtained from the above estimation was used for the determination of exchangeable cations.

(i) Exchangeable calcium and magnesium

The method referred under item 3 (ii) was followed.

(ii) Exchangeable potassium and sodium

The method cited under item 3 (iii) was followed.

4. Lime requirement

Lime requirement was determined by $Ca(OH)_2$ titration method using a pH meter.

B. Analysis of saturation extract

Soil salinity has been measured and expressed in several ways. It is well established that plant response is governed by the salinity of the soil water. Salinity expressed on a dry soil basis is an unsatisfactory measure, since it ignores the water retention capacity of the soil and hence does not indicate the volume of water in which the salt is dissolved (U.S.Salinity Laboratory staff, 1954). It is also well established that plant response to salinity is, in most cases, largely determined by the osmotic potential of the soil water (Bernstein & Hayward, 1958) since electrical conductivity (EC) of the soil is closely related to its osmotic potential and since the saturation percentage of soil represents a reasonably uniform dilution of the water content in the field moisture range of most soils, the electrical conductivity of the saturation extract ( $EC_e$) has been widely used as a measure of the soil salinity (U.S.Salinity Laboratory Staff, 1954).

(1) Preparation of saturation extract.

A 250 g soil was used and the method described in U.S.D.A. - Hand Book No.60 was followed for the preparation of the extract.

(a) pH of the extract

The pH was measured using the glass electrode of a photo-volt pH meter.

(b) Water soluble salts in the extract

The total water soluble salts were measured using solu-bridge-U.S. Salinity laboratory type and the result was expressed in millimhos/cm. Where the ranges of salinity measured was higher than the maximum measurable with the instrument, the extract was suitably diluted and the conductivity of the original extract computed from the dilution factor.

2. Soluble cations and anions.

(a) Calcium and magnesium

5 ml of the saturation extract was made upto 100 ml and 10 ml of this made up solution was used for the determination of Ca and Mg, following the procedure quoted in U.S.D.A. - Hand Book No.60 and the results were expressed as me/litre.

(b) Potassium and sodium

Water soluble potassium and sodium were estimated using EEL flamephotometer, following the method described in U.S.D.A. Hand Book No.60 and the results were expressed as me/litre.

3. (a) Chloride

5 ml of the saturation extract was made upto 100 ml and 10 ml of this made up solution was used for titration against silver nitrate (U.S.D.A. Hand Book No.60).

(b) Sulphate

Sulphate was determined using titrimetic procedure, based on the versenate chelation of the excess barium remaining after barium sulphate precipitation. 5 ml of the saturation extract was diluted to 100 ml and 10 ml from this made up solution was used for each titration (Jackson, 1967).

4. (a) SAR AND KAR

The saturation extract of the soil was prepared according to the method quoted under item B (1) and estimated the calcium, magnesium, potassium and sodium using the methods referred under item (2 a, b) respectively. Then calculated the sodium and potassium adsorption ratios as follows:-

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

$$KAR = \frac{K^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

(U.S.D.A. Hand Book No.60)

(b) Exchangeable sodium percentage

The exchangeable sodium percentage was determined from soluble cations using the relation given below:

$$ESP = \frac{100\ (-0.0126 + 0.01475.\ SAR)}{1 + (-0.0126 + 0.01475.\ SAR)}$$

(U.S.D.A. Hand Book No.60)

5. Saturation percentage.

The method described in U.S.D.A. Hand Book No.60 was followed.

6. Analysis of seasonal variation soil and surface water samples.

Soil samples for studies on seasonal variation in salinity were collected from mounds and pits, from the Pokkali and Kaipad areas since there is an accepted agronomic practice of sowing seeds in mounds. In the Pokkali and Kaipad areas, in the months of March-April, mounds of 1 meter diameter and 1/4 to 3/4 meter high are taken. The height of the mound usually varies depending to the level of the land in relation to the mean sea level. In Vytilla and Payyanur from where periodical samples were collected, the height was about 1/2 meter. The mound to mound distance is about 60 cms. The saline resistant varieties, are sown in the mounds after washing off the salinity and the sprouted seedlings are later spread into the pits also. As against this in recent years there is another practice of germinating the salt resistant paddy seeds in non-saline nurseries and later transplanting them in the mounds in June-July when salinity in the mounds are washed off.

The periodical samples for salinity determination have been collected from 10 mounds, in marked locations in the two regions of Pokkali and Kaipad. The locations were (1) Plot No.19, Rice Research Station, Vytilla (Kerala Agricultural University), Ernakulam District and (2) Survey No.232/2, Kunhimangalam Village, Payyanur, Cannanore District. The pit samples were collected from the space in between these 10 selected mounds.

In the case of Orumundakan lands near Karunagapally the periodical samples were collected from a ploughed field since there is no practice of taking mounds in these areas. The samples were collected from the 10 locations in the selected field, (35 cents southern extremity of 2½ acre plot in Survey No.16578, Padanayarkulangara South Muri, Karunagapally Village, Quilon district), pooled and sub-sampled.

The surface water samples from all these locations were also collected at the time of collection of the soil samples.

The following determinations were made on the soil samples, using the methods already described.

1. pH of the saturation extract

2. EC of the saturation extract

3. Na, K, Ca + Mg, Cl and $SO_4$ content of the saturation extract

Analysis of water samples

pH, EC, Cl and $SO_4$ content of the water samples were determined by the same methods as used for soils.

Table-1

SOIL DESCRIPTION

Profile No.1.

Pokkali soil: Halomorphic (Salt affected by sea water inundation)

Location: Vytilla, Rice Research Station, Plot No.19, Ernakulam district.

Site characteristics:

Elevation almost at sea level, land form plain and flat; microtopography - artificial mounds are taken for paddy cultivation; natural vegetation - halophytic weeds but severely affected with African payal (Salvinia molesta); humid and tropical climate with 3220 mm rainfall and 133 rainy days a year; parent material-lacustrine origin with lateritic washed down material; drainage impeded and ground water table is at 80 cm from the surface in the summer season. Profile moist almost throughout the year, but fully flooded with brackish water during 6 to 8 months in a year. Cultivated during a single season only with salt resistant rice varieties. After the harvest used for Pisciculture especially with prawns.

Profile characteristics

| Depth (cm) | Morphological features |
|---|---|
| 0-10 | Black (7.5 YR 2/0) when moist and dark brown (10 YR 4/3) when dry; clay loam; structureless; moist firm, wet sticky; dry hard; very fine pores abundant; free from concretions and mineral fragments; no pan formation; gradual boundary; acidic - pH 4.65 |

( Table-1 continued)

| | |
|---|---|
| 10 - 30 | Grey (7.5 YR 5/0) when moist and light brownish grey (10 YR 6/2) when dry; clay loam; structureless; moist very firm; wet sticky, dry hard; red and yellow mottles present; pores very few; free from concretions and mineral fragments; very few roots; diffuse and smooth boundary; acidic - pH 5.75. |
| 30 - 53 | Very dark grey (7.5 YR 3/0) when moist and same colour (10 YR 3/1) when dry; clay loam; structureless; moist firm, wet sticky; dry slightly hard; yellow mottles present; no roots; diffuse and smooth boundary; acidic - pH 6.4. |
| 53 - 79 | Dark grey (7.5 YR 4/0) to very dark brown (10 YR 2/2); clay loam; structureless; moist firm; wet sticky; dry very hard; free from mottles; slight clay pan; no roots; acidic - pH 5.4. |

Brief description of the profile

Profile is almost uniform in texture, though there is a slight increase in clay content with depth. Structureless due to puddled waterlogged condition. Profile is acidic in spite of its high conductivity caused by intrusion of sea water. Slight red and yellow mottles observed at 10 - 30 cm depth and yellow mottles at 30 - 53 cm depth and a slight clay pan in the last layer. The ground water table is at 80 cm from the surface in summer, ie. at the time of observation. The conductivity of the saturation extract of the soil is a highly variable in this profile due to periodic tidal ingress of sea water and washing by rain water. Horizon differentiation is not very distinct.

Table-2

SOIL DESCRIPTION

**Profile No.2**

**Marshy soil:** Halomorphic (severely salt affected by direct sea water intrusion)

**Location:** Puthuvaippu - Southern side of the Ochenthuruthu, Puthuvaippu Road, Ernakulam district. Surround by sea on 3 sides except a narrow strip of road near Ochenthuruthu.

**Site characteristics:**

Elevation slightly below the sea level; land form - plain and flat; erosion by sea prevented by rubble walls; microtopography - nil; natural vegetation - wild growth of *Argemone mexicana*; humid tropical climate with a mean annual rainfall of 3400 mm; parent material is a recent marine deposits formed either by upheaval or silting. The land has risen to nearly sea level only about 25 years back; drainage impeded; the profile is moist throughout the year; not appreciably disturbed by man and trials are being done to bring the area under paddy cultivation.

**Profile description**

| Depth (cm) | Morphological features |
|---|---|
| 0 - 5 | Black (5 Y 2/2); silty clay; strong sub angular blocky; moist very friable; wet slightly sticky; dry hard; free from concretions and mineral fragments; many roots abrupt boundary; pH nearly neutral 6.9. |

(Table-2 continued)

| | |
|---|---|
| 5-10 | Dark olive grey( 5 Y 3/2) to black (5 Y 2/2); silty clay; angular blocky; moist friable; wet very sticky; dry extremely hard; roots very few; abrupt boundary; slightly acidic - pH 6.35. |
| 10-15 | Black (5 Y 2/2); silty clay; angular blocky; moist friable; wet very sticky; dry very hard; no roots; abrupt boundary; acidic - pH 5.45. |
| 15-25 | Black (5 Y 2/1); silty clay; angular blocky; moist friable; wet very sticky; dry extremely hard; no roots; free from concretions and mineral fragments; alkaline - pH 7.3. |

Brief description of the profile

The profile is fairly uniform in texture; but a slight increase in clay content with depth. Structure varies from sub angular blocky to angular blocky. Soil reaction ranges from slightly acidic to alkaline. The surface layer of this profile has got the maximum conductivity in the saturation extract (226.3 mmhos/cm). Free from concretions and mineral fragments. Wild growth of Argemone mexicana (halophytic weed) can be seen throughout the site. The water table is at 25 cm from the surface. The profile is situated very close (about 300 meters) to the sea coast. The horizon differentiation is not distinct.

Table-3

SOIL DESCRIPTION

Profile No.3

Pokkali soil: Halomorphic

Location: Cherai, Manappad, Southern side of the Varapolly Cherai Road, Ernakulam district.

Site characteristics:

Elevation almost at sea level; land form plain and flat; microtopography - artificial mounds are taken for paddy cultivation; humid tropical climate with a mean annual rainfall of 3200 mm; profile moist almost throughout the year; drainage impeded; no evidence of erosion; ground water table is at 35 cm from the surface; cultivated during a single crop season with salt resistant varieties.

Profile description

| Depth (cm) | Morphological features |
|---|---|
| 0-10 | Very dark grey (5 Y 2/2); clay loam; structureless; moist firm; wet sticky; dry slightly hard, many roots; concretions and mineral fragments absent diffuse boundary; acidic - pH 3.2. |
| 10-15 | Black (5 Y 2/2); clay loam; structureless; moist firm; wet sticky; dry hard; free from concretions and mineral fragments; very few roots; diffuse boundary; acidic - pH 3.15. |
| 15-35 | Black (5 Y 2/1); clay loam; structureless; moist firm; wet sticky; dry very hard; free from concretions and mineral fragments; no roots; acidic - pH 3.2. |

(Table-3 continued)

Brief description of the profile

This profile is also uniform in texture, but no pattern in the distribution of clay with depth. The structure is destroyed due to puddled waterlogged condition. The profile is acidic in reaction throughout and the conductivity of the saturation extract varies from 91.8 to 138.8 mmhos/cm. The profile is free from concretions and mineral fragments. The horizon differentiation is not sharp and the ground water table is at 35 cm from the surface.

Table-4

SOIL DESCRIPTION

**Profile No.4**

**Orumundakan soils:** Halomorphic (salt water inundation from coastal back waters)

**Location:** Karunagapally - 4 km west of national high way, Thurayilkunnu near Chanda kayal (300 meters); Quilon district.

**Site characteristics:**

Elevation slightly above the sea level; land plain and almost flat; microtopography - nil; natural vegetation - halophytic weeds and paddy; climate humid tropical with mean annual rainfall of 1800 mm; parent material-lacustrine deposit of sandy origin; profile moist almost throughout the year after a depth of few centimeters. The land is under water for six to seven months (June - November) cultivated during a single season with salt resistant local variety viz. "Orumundakan" of 270 days duration, which is the only variety which tolerates the high levels of salinity.

**Profile characteristics**

| Depth (cm) | Morphological features |
|---|---|
| 0-28 | Dark grey (2.5 Y 4/0) to grey (2.5 Y 2/0) sand; massive-single grain; moist loose; wet non-sticky; dry loose; red and yellow mottles present; roots very few; abrupt boundary; acidic - pH 3.1. |

(Table-4 continued)

| | |
|---|---|
| 28-48 | Dark grey (2.5 Y 4/0); sand; massive single grain; moist loose; wet non-sticky dry loose; red and yellow mottles present; no roots; abrupt boundary; acidic - pH 3.0. |
| 28-66 | Grey (2.5 Y 5/0) to dark grey (2.5 Y 4/0) sand; massive - single grain; moist very friable; wet slightly sticky; dry loose; concretions and mineral fragments absent; no roots; acidic - pH 3.3. |

Brief description of the profile

The profile is uniform in texture, but there is a very slight increase in clay content with depth. The profile is acidic throughout and the conductivity of the saturation extract ranges from 20.2 to 32.3 mmhos/cm. Red and yellow mottles were present in the first two layers. The horizon differentiation is not very sharp. The ground water table is at 66 cm from the surface.

Table-5

SOIL DESCRIPTION

Profile No.5

Kaipad soils: Halomorphic (deltaic alluvium)

Location: Vayalappra, Cheruthasham Village; Cannanore district.

Site characteristics:

Elevation slightly below the sea level; land form - plain and flat; microtopography, - artificial mounds are formed for paddy cultivation, natural vegetation - paddy and halophytic weeds; humid tropical climate with a mean annual rainfall of 2520 mm; parent material riverine deposits; drainage highly impeded; no evidence of erosion. Except the surface layer the profile is moist almost throughout the year. The land is under water from June to November. The river 'Ramapuram' is by the side of the site. The soil is disturbed to a depth of 9 to 12". Only one crop is taken, using salt resistant local variety viz., "Kuthiru", water recedes from the beginning of December.

Profile characteristics

| Depth (cm) | Morphological features |
|---|---|
| 0-15 | Dark yellowish brown (10 YR 3/4) to reddish brown (5 YR 4/3); sandy clay; structureless; moist friable; wet sticky; dry slightly hard; free from concretions and mineral fragments; many roots; clear and smooth boundary; acidic - pH 5.1. |

(Table-5 continued)

| | |
|---|---|
| 15-30 | Very dark greyish brown (10 YR 3/2) to reddish grey (5 YR 5/2); sandy clay loam; blocky; moist firm; wet sticky, dry hard; few brownish yellow mottles; very few roots; clean and smooth boundary; acidic - pH 4. |
| 30-60 | Very dark grey (10 YR 3/1) to reddish brown (5 YR 2/2); sandy loam; blocky; moist very friable, wet slightly sticky; dry slightly hard; few yellow mottles; diffuse and smooth boundary; no roots; acidic - pH 2.8 |
| 60-110 | Black (10 YR 2/1); to very dark grey (5 YR 3/1); sandy loam; blocky; moist very friable; wet slightly sticky; dry slightly hard; concretion and mineral fragments absent; no roots; acidic - pH 3.1. |

Brief description of the profile

The texture of the profile varies from sandy clay loam to sandy loam. The structure ranges from structureless to blocky. The clay content though initially shows an increase with depth further decreases with depth. The profile is acidic throughout and the conductivity of the saturation extract falls between 30.8 to 103.1 mmhos/cm. Brownish yellow mottles are present in the second and third layer of this profile. The horison differentiation is very sharp. The ground water table is at 110 cm from the surface at the time of sampling (summer).

Table-6

SOIL DESCRIPTION

Profile No.6

Kaipad soil: Halomorphic (Deltaic alluvium)

Location: Pallikkara, Cherukunnu Village, Cannanore district.

Site characteristics

Elevation almost at sea level; land form - plain and almost flat; microtopography - artificial mounds are taken for paddy cultivation; natural vegetation - halophytic weeds and paddy; humid tropical climate with a mean annual rainfall of 2520 mm; parent material - riverine deposits; drainage highly impeded; no evidence of erosion; moist almost throughout the year except the surface layer (0-25 cm). The soil disturbed upto a depth of 12". The 'Pazhayangadi' river is adjacent to the site and the salt water intrusion from the Arabian sea takes place through the river; only one crop is grown, as described under the site characteristics of Profile No.5.

Profile characteristics

| Depth (cm) | Morphological features |
|---|---|
| 0-25 | Dark yellowish brown (10 YR 3/4) to dark brown (10 YR 4/3); sandy loam; structureless; moist very friable; wet slightly sticky; dry slightly hard; yellow mottles; few roots; clear and smooth boundary; slightly acidic - pH 6.9 |

(Table-6 continued)

| | |
|---|---|
| 25-45 | Dark brown (10 YR 3/3) to dark brown (10 YR 1/3) clay loam; blocky; moist firm; wet sticky; dry hard; yellow mottles; very few roots; diffuse and smooth boundary; neutral - pH 7.00. |
| 45-70 | Dark brown (10 YR 3/3) to dark grey brown (10 YR 4/2); sandy clay loam; blocky; moist firm; wet very sticky; dry very hard; clay pan present; free from concretion and mineral fragments; abrupt boundary; slightly acidic - pH 6.7. |
| 70-95 | Very dark grey brown (10 YR 3/2) to dark grey brown (10 YR 4/2); loam; blocky; moist firm; wet sticky and dry slightly hard; clay pan absent; free from concretions and mineral fragments; no roots; acidic - pH 5.4. |

Brief description of the profile

The profile varies in texture from sandy loam to sandy clay loam and in structure from structureless to blocky. The soil reaction ranges from acidic to neutral and the conductivity ranges between 29.4 to 72.1 mmhos/cm. Yellow mottles in the first and second layers and clay pan in third layer are present. The horizon differentiation is distinct. The ground water table is at 95 cm from the surface of the profile at the time of sampling.

# RESULTS

# RESULTS

## A. PHYSICAL CHARACTERISTICS

### 1. Mechanical composition

Table-7 presents data on the mechanical composition of the horizon samples from the 6 profiles under study. The texture of the soil is uniform in Vytilla, Puthuvaippu, Karunagapally and Vayalappra profiles. The texture varies from clay loam to clay in Cherai profile and sandy loam to sandy clay loam in Pallikkara profile. The sand fraction of the samples vary from 14.7 to 90.4 per cent in surface layers of Puthuvaippu and Karunagapally profiles respectively. Similarly the clay content vary from 5 per cent in the Karunagapally profile to 48.5 per cent in the Puthuvaippu profile. It is significant to note that in the Pokkali, Kaipad and Orumundakan locations the silt content vary from 1 to 22 per cent. The various horizons of the Puthuvaippu profile have more than 27 per cent silt. Thus the finer fractions represented by silt plus clay is more than 80 per-cent in all the horizons of the Puthuvaippu profile, while it is not more than 56 per cent in any of the other profiles.

The results on the variation in clay and silt content of the various horizons of the 6 profiles do not bring out any clear cut pattern. However, a pattern emerges, when the finer fractions represented by silt plus clay are considered.

Table-7. Mechanical composition of the profile samples

| Sample No. | Location | Depth (cm) | Profile No. | Percentage on oven dry basis: Coarse sand | Fine sand | Silt | Clay | Textural class |
|---|---|---|---|---|---|---|---|---|
| **Pokkali and Orumundakan** | | | | | | | | |
| 1. | Vytilla | 0-10 | 1 | 28.0 | 19.1 | 13.7 | 36.2 | Clay loam |
| 2. | | 10-30 | | 28.9 | 19.4 | 15.0 | 36.2 | Clay loam |
| 3. | | 30-53 | | 40.7 | 17.6 | 1.8 | 36.9 | Clay loam |
| 4. | | 53-79 | | 38.2 | 19.3 | 3.9 | 37.2 | Clay loam |
| 5. | Puthuvaippu | 0-5 | 2 | 1.5 | 13.2 | 32.5 | 48.5 | Silty clay |
| 6. | | 5-10 | | 1.0 | 13.9 | 27.5 | 53.5 | Silty clay |
| 7. | | 10-15 | | 0.3 | 15.2 | 28.2 | 50.7 | Silty clay |
| 8. | | 15-25 | | 0.3 | 15.9 | 27.7 | 52.1 | Silty clay |
| 9. | Cherai | 0-10 | 3 | 15.8 | 24.8 | 19.8 | 35.1 | Clay loam |
| 10. | | 10-15 | | 23.4 | 17.6 | 22.0 | 32.5 | Clay loam |
| 11. | | 15-35 | | 16.6 | 22.7 | 16.2 | 40.0 | Clay |
| 12. | Karunagapally | 0-28 | 4 | 78.3 | 12.1 | 4.3 | 5.0 | Sand |
| 13. | | 28-48 | | 85.2 | 8.8 | 1.2 | 6.2 | Sand |
| 14. | | 48-68 | | 84.8 | 7.8 | 1.0 | 6.2 | Sand |
| **Kaipad** | | | | | | | | |
| 15. | Vayalappra | 0-15 | 5 | 54.5 | 13.7 | 6.2 | 20.0 | Sandy clay loam |
| 16. | | 15-30 | | 62.8 | 9.5 | 4.1 | 23.1 | Sandy clay loam |
| 17. | | 30-60 | | 63.7 | 11.9 | 5.0 | 18.6 | Sandy clay loam |
| 18. | | 60-110 | | 56.6 | 19.0 | 10.1 | 13.7 | Sandy clay loam |
| 19. | Pallikkara | 0-25 | 6 | 55.7 | 14.3 | 10.2 | 19.0 | Sandy loam |
| 20. | | 25-45 | | 53.2 | 14.4 | 4.7 | 27.5 | Sandy clay loam |
| 21. | | 45-70 | | 41.9 | 22.8 | 4.2 | 30.0 | Sandy clay loam |
| 22. | | 70-95 | | 57.1 | 9.6 | 9.7 | 21.5 | Sandy clay loam |

In the Vytilla, Puthuvaippu, Vayalappra and Karunagapally profiles a decrease in the content of finer fractions with depth is observed. In the Cherai and Pallikkara profiles an increasing trend in the finer fraction with depth is, however, noted.

2. Single value constants

The physical properties of the profiles and surface samples represented by bulk density, particle density, water holding capacity, percentage pore space and volume expansion are presented in tables 8(a) & (b).

(a) Particle density.

The values for particle density range between 2.01 and 2.74, 2.07 and 3.30, 2.36 and 2.45, 1.99 and 2.22, 2.52 and 2.73, 2.32 and 2.57 in the six profiles. A steady decrease in the particle density is observed in the Cherai and Karunagapally profiles (3 and 4). In the rest of the profiles no distinct pattern is evident. The maximum value of 3.3 is recorded in the sub-surface layer of Puthuvaippu profile (2) and the minimum value of 1.99 is noted in the last two horizons of Karunagapally profile (4). The particle density of the surface samples from various locations of Pokkali, Kaipad and Orumundakan lands vary between 1.62 and 2.86.

(b) Bulk density.

This shows a decreasing trend with increase in depth in Vytilla and Cherai profiles (1 and 3). In the Vayalappra

Table-8(a). Physical properties of the profile samples

| Sample No. | Location | Depth (cm) | Profile No. | Bulk density | Particle density | Maximum W.H.C. (%) | Pore space (%) | Volume expansion |
|---|---|---|---|---|---|---|---|---|
| **Pokkali and Orumundakan** | | | | | | | | |
| 1. | Vytilla | 0-10 | 1 | 1.44 | 2.74 | 36.7 | 49.4 | 4.7 |
| 2. | | 10-30 | | 1.40 | 2.45 | 33.7 | 49.6 | 8.7 |
| 3. | | 30-53 | | 1.34 | 2.57 | 34.1 | 50.8 | 1.7 |
| 4. | | 53-79 | | 1.26 | 2.01 | 33.6 | 40.0 | 0.9 |
| 5. | Puthuvaippu | 0-5 | 2 | 1.11 | 2.07 | 51.4 | 56.3 | 16.2 |
| 6. | | 5-10 | | 1.25 | 3.30 | 48.9 | 70.8 | 11.0 |
| 7. | | 10-15 | | 1.21 | 2.32 | 41.9 | 59.1 | 9.4 |
| 8. | | 15-25 | | 1.14 | 2.52 | 44.4 | 64.7 | 5.2 |
| 9. | Cherai | 0-10 | 3 | 1.12 | 2.45 | 45.2 | 59.3 | 4.1 |
| 10. | | 10-15 | | 1.11 | 2.44 | 46.6 | 59.2 | 2.2 |
| 11. | | 15-35 | | 1.08 | 2.36 | 46.8 | 59.1 | 1.2 |
| 12. | Karunagapally | 0-28 | 4 | 1.43 | 2.22 | 24.0 | 36.8 | 0.5 |
| 13. | | 28-48 | | 1.36 | 1.99 | 23.1 | 33.9 | 0.9 |
| 14. | | 48-68 | | 1.58 | 1.99 | 19.2 | 10.9 | 0.0 |
| **Kaipad** | | | | | | | | |
| 15. | Vayalappra | 0-15 | 5 | 1.24 | 2.56 | 39.2 | 53.8 | 0.1 |
| 16. | | 15-30 | | 1.27 | 2.52 | 38.4 | 52.5 | 2.1 |
| 17. | | 30-60 | | 1.26 | 2.73 | 41.1 | 56.4 | 1.9 |
| 18. | | 60-110 | | 1.41 | 2.65 | 40.1 | 60.0 | 2.8 |
| 19. | Pallikkara | 0-25 | 6 | 1.23 | 2.35 | 39.4 | 52.4 | 4.6 |
| 20. | | 25-45 | | 1.27 | 2.57 | 43.2 | 55.6 | 8.0 |
| 21. | | 45-70 | | 1.25 | 2.39 | 44.3 | 54.5 | 10.3 |
| 22. | | 70-95 | | 1.17 | 2.32 | 45.2 | 53.5 | 5.6 |

profile (5) an initial decrease followed by a general increase is observed. In general, the values range between 1.08 and 1.53. Except the Karunagapally and Vayalappra profiles (4 and 5) the last horizon of all the other profiles has the minimum value for bulk density. The bulk density of the surface samples vary from 1.02 to 1.39.

(c) Pore space.

A general trend to increase pore space with depth is observed in some profiles (1, 2 and 6). The percentage of pore space vary from 10.9 to 70.8 per cent. The minimum and maximum values are noticed in the Karunagapally and Puthuvaippu profiles. The percentage of pore space of surface samples from various locations range between 17.0 and 65.0 per cent. The surface samples of Puthuvaippu exhibited the maximum values for percentage pore space.

(d) Maximum water holding capacity.

In the Cherai and Pallikkara profiles (3 and 6) an increase in maximum water holding capacity with increase in depth is observed. The values for the 6 profiles, in the order, vary from 33.6 to 36.7, 41.9 to 51.4, 45.2 to 46.8, 19.2 to 24.0, 38.4 to 41.1 and 39.4 to 45.2. The Karunagapally profile (4) shows a decrease in water holding capacity with an increase in depth. Generally the maximum water holding capacity of the surface samples vary from 9.1 to 67.3 and the sample from Thuravoor shows the maximum value of 67.3 per cent.

Table-8(b). Physical properties of the surface samples

| Sample No. | Location | Bulk density | Particle density | Maximum W.H.C. % | Pore space % | Volume expansion |
|---|---|---|---|---|---|---|
| **Pokkali and Orumundakan** | | | | | | |
| 23. | Madathilthara | 1.22 | 1.62 | 12.2 | 19.8 | 0.4 |
| 24. | Padanayar-kulangara | 1.39 | 1.84 | 16.3 | 29.4 | 1.1 |
| 25. | Chandakayal | 1.27 | 1.83 | 16.8 | 27.5 | 1.2 |
| 26. | Thodiyoor | 1.24 | 1.82 | 9.1 | 17.0 | 1.9 |
| 27. | Puthuvaippu | 1.02 | 2.29 | 52.8 | 51.2 | 3.5 |
| 28. | Puthuvaippu | 1.08 | 2.20 | 47.3 | 65.0 | 3.6 |
| 29. | Cherai | 1.16 | 2.32 | 43.6 | 58.6 | 1.5 |
| 30. | Thuravoor | 1.02 | 2.25 | 67.5 | 62.8 | 18.3 |
| **Kaipad** | | | | | | |
| 31. | Vayalappra | 1.38 | 2.34 | 46.1 | 58.6 | 12.4 |
| 32. | Vayalappra | 1.19 | 2.42 | 40.7 | 55.6 | 2.6 |
| 33. | Vayalappra | 1.21 | 2.34 | 40.8 | 55.3 | 0.5 |
| 34. | Vengara | 1.22 | 2.37 | 44.9 | 53.0 | 7.7 |
| 35. | Vengara | 1.28 | 2.21 | 31.4 | 43.6 | 0.1 |
| 36. | Kannapuram | 1.35 | 1.80 | 18.9 | 24.3 | 0.0 |
| 37. | Cheruthazham | 1.14 | 2.16 | 45.0 | 50.3 | 2.8 |
| 38. | Pallikkara | 1.18 | 2.46 | 42.4 | 53.3 | 0.0 |
| 39. | Pallikkara | 1.22 | 2.39 | 43.3 | 53.5 | 5.7 |
| 40. | Muttil | 1.20 | 2.46 | 43.4 | 53.6 | 2.8 |
| 41. | Kattukulam | 1.30 | 2.86 | 44.8 | 59.2 | 7.5 |
| 42. | Mundappuram | 1.18 | 2.32 | 44.8 | 55.6 | 8.6 |
| 43. | Thavom | 1.02 | 1.91 | 43.3 | 51.5 | 0.0 |
| 44. | Chembellikundu | 1.23 | 2.58 | 42.4 | 55.2 | 1.2 |
| 45. | Cherukunnu | 1.09 | 2.41 | 47.1 | 59.8 | 4.2 |
| 46. | Kannaru | 1.37 | 2.44 | 40.8 | 57.6 | 3.8 |
| 47. | Thurithi | 1.26 | 2.48 | 40.1 | 52.4 | 4.3 |
| 48. | Ezhom | 1.29 | 2.37 | 45.5 | 52.6 | 14.3 |
| 49. | Pinarai | 1.24 | 2.27 | 44.2 | 51.3 | 11.9 |
| 50. | Pazhayangadi | 1.26 | 2.30 | 44.5 | 52.3 | 12.8 |
| 51. | Pazhayangadi | 1.39 | 2.56 | 40.9 | 56.0 | 8.9 |
| 52. | Kunhimangalam | 1.19 | 2.37 | 42.6 | 52.2 | 2.0 |
| 53. | Ramanthali | 1.27 | 2.47 | 40.7 | 51.7 | 4.6 |
| 54. | Ramanthali | 1.18 | 2.20 | 46.6 | 51.1 | 8.8 |
| 55. | Ezhimala | 1.23 | 2.19 | 45.1 | 48.6 | 11.2 |
| 56. | Ezhimala | 1.12 | 2.41 | 43.0 | 57.6 | 0.0 |

(e) Volume expansion.

In the Puthuvaippu and Cherai profiles the volume expansions suffers a decrease with an increase in depth. Pallikkara profile revealed an increasing trend upto the last horizon. The surface layer of the Puthuvaippu profile (2) has the maximum value of 16.2 and the last horizon of the Karunagapally profile (4) has the least value of 0.01. The values for the volume expansion of the surface samples range between 0 and 18.3. The maximum value is recorded in the surface sample from Thuravoor.

B. CHEMICAL CONSTITUENTS

1. Organic carbon

No regular pattern is observed in the distribution of organic carbon. The Puthuvaippu profile shows an increasing trend with increase in depth. The maximum value of 2.63 per cent is also recorded in the last horizon of this profile and the least value of 0.21 per cent in the surface layer of Pallikkara profile. The organic carbon content of the surface samples from different places vary between 0.12 and 3.69 per cent. Surface samples from Thuravoor (Pokkali) and Chembellikundu (Kaipad) show the maximum and minimum value for organic carbon.

2. Total nitrogen

Considerable variation is not observed in the total nitrogen content between layers in the same profile. The

Table-9(a). Organic carbon, nitrogen, C/N ratio and organic matter of the profile samples

| Sample No. | Location | Depth (cm) | Profile No | Organic carbon % | Nitrogen % | C/N ratio | Organic matter % |
|---|---|---|---|---|---|---|---|
| **Pokkali and Orumundakan** | | | | | | | |
| 1. | Vytilla | 0-10 | 1 | 1.27 | 0.056 | 22.68 | 2.18 |
| 2. | | 10-30 | | 0.85 | 0.039 | 21.79 | 1.46 |
| 3. | | 30-53 | | 1.22 | 0.057 | 21.40 | 2.10 |
| 4. | | 53-79 | | 1.39 | 0.067 | 20.75 | 2.39 |
| 5. | Puthuvaippu | 0-5 | 2 | 2.43 | 0.078 | 31.15 | 4.18 |
| 6. | | 5-10 | | 2.45 | 0.084 | 29.17 | 4.21 |
| 7. | | 10-15 | | 2.48 | 0.069 | 35.94 | 4.27 |
| 8. | | 15-25 | | 2.63 | 0.073 | 36.03 | 4.52 |
| 9. | Cherai | 0-10 | 3 | 2.10 | 0.070 | 30.00 | 3.61 |
| 10. | | 10-15 | | 2.04 | 0.058 | 35.17 | 3.51 |
| 11. | | 15-35 | | 2.19 | 0.063 | 34.76 | 3.77 |
| 12. | Karunagapally | 0-28 | 4 | 0.38 | 0.008 | 47.50 | 0.65 |
| 13. | | 28-48 | | 0.41 | 0.011 | 36.36 | 0.71 |
| 14. | | 48-68 | | 0.34 | 0.011 | 30.90 | 0.58 |
| **Kaipad** | | | | | | | |
| 15. | Vayalappra | 0-15 | 5 | 0.75 | 0.028 | 26.79 | 1.29 |
| 16. | | 15-30 | | 0.57 | 0.021 | 27.14 | 0.98 |
| 17. | | 30-60 | | 0.79 | 0.017 | 46.47 | 1.36 |
| 18. | | 60-110 | | 0.75 | 0.014 | 53.57 | 1.29 |
| 19. | Pallikkara | 0-25 | 6 | 0.21 | 0.022 | 9.55 | 0.36 |
| 20. | | 25-45 | | 0.15 | 0.011 | 13.64 | 0.26 |
| 21. | | 45-70 | | 0.27 | 0.011 | 24.55 | 0.45 |
| 22. | | 70-95 | | 0.56 | 0.016 | 35.00 | 0.96 |

surface horizon contain the maximum content of nitrogen in the Cherai, Vayalappra and Pallikkara profiles. No steady trend is noticed in the distribution of this nutrient. The sub-surface and surface horizons of the Puthuvaippu and Karunagapally profiles respectively contained the maximum (0.084 per cent) and the minimum (0.008 per cent) quantity of this nutrient. The total nitrogen content of the surface samples range from 0.011 to 0.109 per cent. Emhom and Thuravoor samples contain the minimum and maximum respectively.

3. <u>C/N ratio</u>

The C/N ratio exhibit a steady decreasing and then an increasing trend with depth in the Vytilla profile. The Karunagapally profile reveals a steady decreasing trend with increase in depth. The Vayalappra and Pallikkara profiles show an opposite trend. The Puthuvaippu profile shows an initial decrease followed by a steady increase with depth. The Cherai profile, on the other hand, shows an increase accompanied by a decrease. The values of C/N ratio vary from 9.55 to 53.57. The C/N ratio of the surface samples range between 7.5 and 56.25. All the surface samples from Pokkali and Orumundakan areas have a ratio above 26.6 and that of the Kaipad range from 7.5 to 49.09.

4. <u>Total phosphorus</u>

In general, no distinct pattern is evident in the distribution of this nutrient. A steady decreasing trend is noticed in Puthuvaippu profile. The values for total phosphorus range

Table-9(b). Organic carbon, nitrogen, C/N ratio and organic matter of the surface samples

| Sample No | Location | Organic carbon % | Nitrogen % | C/N ratio | Organic matter % |
|---|---|---|---|---|---|
| **Pokkali and Orumundakan** | | | | | |
| 23. | Madathilthara | 1.17 | 0.036 | 32.50 | 2.01 |
| 24. | Padanayarkulangara | 1.77 | 0.039 | 45.35 | 3.04 |
| 25. | Chandakayal | 1.35 | 0.024 | 56.25 | 2.32 |
| 26. | Thodiyoor | 1.50 | 0.033 | 45.45 | 2.58 |
| 27. | Puthuvaippu | 1.41 | 0.053 | 26.60 | 2.43 |
| 28. | Puthuvaippu | 1.92 | 0.050 | 38.40 | 3.30 |
| 29. | Cherai | 1.62 | 0.044 | 36.82 | 2.79 |
| 30. | Thuravoor | 3.69 | 0.109 | 33.85 | 6.35 |
| **Kaipad** | | | | | |
| 31. | Vayalappra | 0.75 | 0.025 | 30.00 | 1.29 |
| 32. | Vayalappra | 0.78 | 0.023 | 33.91 | 1.34 |
| 33. | Vayalappra | 0.93 | 0.019 | 48.95 | 1.60 |
| 34. | Vengara | 0.56 | 0.016 | 35.00 | 0.96 |
| 35. | Vengara | 0.60 | 0.021 | 28.57 | 1.03 |
| 36. | Kannapuram | 0.55 | 0.023 | 23.91 | 0.95 |
| 37. | Cheruthazham | 0.54 | 0.014 | 38.57 | 0.93 |
| 38. | Pallikkara | 0.54 | 0.011 | 49.09 | 0.93 |
| 39. | Pallikkara | 0.39 | 0.026 | 15.00 | 0.67 |
| 40. | Muttil | 0.60 | 0.029 | 20.69 | 1.03 |
| 41. | Kattukulam | 0.78 | 0.023 | 33.91 | 1.34 |
| 42. | Mundappuram | 0.72 | 0.018 | 40.00 | 1.24 |
| 43. | Thavom | 0.27 | 0.013 | 20.77 | 0.46 |
| 44. | Chembellikundu | 0.12 | 0.016 | 7.50 | 0.21 |
| 45. | Cherukunnu | 0.81 | 0.028 | 28.93 | 1.39 |
| 46. | Kannaru | 0.35 | 0.014 | 25.00 | 0.60 |
| 47. | Thuruthi | 0.62 | 0.013 | 47.69 | 1.07 |
| 48. | Ezhom | 0.51 | 0.011 | 46.36 | 0.88 |
| 49. | Pinarai | 0.54 | 0.014 | 38.57 | 0.93 |
| 50. | Pazhayangadi | 0.59 | 0.024 | 24.58 | 1.01 |
| 51. | Pazhayangadi | 0.28 | 0.018 | 15.56 | 0.49 |
| 52. | Kunhimangalam | 0.48 | 0.015 | 32.00 | 0.83 |
| 53. | Ramanthali | 0.35 | 0.029 | 12.06 | 0.60 |
| 54. | Ramanthali | 0.56 | 0.021 | 26.67 | 0.96 |
| 55. | Ezhimala | 0.59 | 0.018 | 32.78 | 1.01 |
| 56. | Ezhimala | 0.68 | 0.024 | 28.33 | 1.17 |

between trace and 0.019 per cent. The phosphorus content of the surface samples vary from trace to 0.02 per cent. The highest total phosphorus content is recorded in the Puthuvaippu profile.

5. Total calcium

The calcium content vary between 0.03 and 0.34 per cent. The Karunagapally, Vayalappra and Pallikkara profiles reveal an increasing trend with depth. The Puthuvaippu profile shows a steady decreasing trend and the Vytilla profile an initial increase followed by a steady decrease in the distribution of this nutrient with depth. The Cherai and Karunagapally profiles show the maximum and minimum values. The total calcium content of the surface samples vary between 0.03 and 0.32 per cent.

6. Total magnesium

The Cherai profile shows an increasing trend with depth in the distribution of this nutrient. None of the other profiles reveal a clear cut pattern. The values range between 0.13 and 0.75 per cent. The sub-surface layer of Puthuvaippu profile has the maximum value. The total magnesium content of the surface samples range from 0.19 to 0.89 per cent. It is however, significant to note that in all the profiles the total magnesium content is higher than the Calcium content.

7. Total potassium

The values of this nutrient range from 0.05 to 0.63

Table-40(a). Total P, Ca, Mg, K and Na of the profile samples

| Sample No. | Location | Depth (cm) | Profile No. | Percentage on oven dry basis | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | P | Ca | Mg | K | Na |
| **Pokkali and Orumundakan** | | | | | | | | |
| 1. | Vytilla | 0-10 | 1 | 0.004 | 0.08 | 0.23 | 0.30 | 0.25 |
| 2. | | 10-30 | | 0.001 | 0.09 | 0.24 | 0.22 | 0.25 |
| 3. | | 30-53 | | 0.004 | 0.06 | 0.34 | 0.22 | 0.24 |
| 4. | | 53-79 | | 0.003 | 0.05 | 0.33 | 0.18 | 0.22 |
| 5. | Puthuvaippu | 0-5 | 2 | 0.019 | 0.30 | 0.57 | 0.60 | 3.63 |
| 6. | | 5-10 | | 0.018 | 0.28 | 0.55 | 0.63 | 3.38 |
| 7. | | 10-15 | | 0.018 | 0.27 | 0.75 | 0.60 | 3.31 |
| 8. | | 15-25 | | 0.016 | 0.25 | 0.56 | 0.58 | 3.00 |
| 9. | Cherai | 0-10 | 3 | 0.009 | 0.23 | 0.34 | 0.63 | 2.50 |
| 10. | | 10-15 | | 0.009 | 0.34 | 0.44 | 0.63 | 2.63 |
| 11. | | 15-35 | | 0.008 | 0.13 | 0.45 | 0.60 | 2.50 |
| 12. | Karunagapally | 0-28 | 4 | Tr | 0.03 | 0.15 | 0.10 | 0.23 |
| 13. | | 28-48 | | Tr | 0.05 | 0.17 | 0.08 | 0.20 |
| 14. | | 48-68 | | Tr | 0.09 | 0.13 | 0.05 | 0.13 |
| **Kaipad** | | | | | | | | |
| 15. | Vayalappra | 0-15 | 5 | 0.004 | 0.10 | 0.29 | 0.22 | 0.61 |
| 16. | | 15-30 | | 0.003 | 0.11 | 0.29 | 0.22 | 0.25 |
| 17. | | 30-60 | | 0.004 | 0.15 | 0.28 | 0.20 | 0.28 |
| 18. | | 60-110 | | 0.004 | 0.18 | 0.40 | 0.18 | 0.28 |
| 19. | Pallikkara | 0-25 | 6 | 0.006 | 0.15 | 0.35 | 0.25 | 0.50 |
| 20. | | 25-45 | | 0.007 | 0.18 | 0.39 | 0.28 | 0.36 |
| 21. | | 45-70 | | 0.008 | 0.19 | 0.42 | 0.28 | 0.36 |
| 22. | | 70-95 | | 0.006 | 0.21 | 0.29 | 0.25 | 0.31 |

per cent. The Vytilla, Cherai, Karunagapally and Vayalappra show a steady decreasing trend with increase in depth. The total potassium content of the surface samples from various places vary between 0.10 and 0.58 per cent.

8. Total sodium

The sodium values range from 0.22 to 3.63 per cent. In all the profiles except the Cherai profile a general decreasing trend is observed with depth. The total sodium content of the surface samples from various locations range between 0.31 and 3.03 per cent.

9. Sesquioxides

The surface and the sub-surface horizons of Puthuvaippu and Karunagapally profiles show the highest value of 21.28 per cent and the least value of 2.32 per cent for total sesquioxides. The Vytilla and Karunagapally profiles show a steady decreasing trend with increase in depth. In the Cherai profile the sesquioxide content increases with depth. A general increasing trend is observed in the Vayalappra profile and a general decreasing trend in the Pallikkara profile.

10. Iron oxide

The $Fe_2O_3$ content range between 0.29 and 13.8 per cent. The lowest and highest values are recorded in the sub-surface layers of Karunagapally and Cherai profiles. A decreasing trend is evident in the Karunagapally profile.

Table-10(b). Total P, Ca, Mg, K and Na of the surface samples

| Sample No. | Location | Percentage on oven dry basis | | | | |
|---|---|---|---|---|---|---|
| | | P | Ca | Mg | K | Na |
| **Pokkali and Orumundakan** | | | | | | |
| 23. | Madathilthara | 0.003 | 0.06 | 0.37 | 0.10 | 0.57 |
| 24. | Padanayarkulangara | 0.003 | 0.06 | 0.25 | 0.10 | 0.49 |
| 25. | Chandakayal | 0.004 | 0.03 | 0.39 | 0.16 | 0.56 |
| 26. | Thodiyoor | 0.008 | 0.12 | 0.56 | 0.20 | 0.49 |
| 27. | Puthuvaippu | 0.022 | 0.32 | 0.65 | 0.58 | 2.88 |
| 28. | Puthuvaippu | 0.020 | 0.27 | 0.88 | 0.55 | 3.03 |
| 29. | Cherai | 0.017 | 0.14 | 0.47 | 0.48 | 2.18 |
| 30. | Thuravoor | 0.012 | 0.20 | 0.50 | 0.63 | 0.46 |
| **Kaipad** | | | | | | |
| 31. | Vayalappra | 0.008 | 0.07 | 0.26 | 0.43 | 0.88 |
| 32. | Vayalappra | 0.007 | 0.08 | 0.24 | 0.48 | 1.94 |
| 33. | Vayalappra | 0.008 | 0.10 | 0.24 | 0.25 | 1.85 |
| 34. | Vengara | 0.006 | 0.04 | 0.33 | 0.28 | 0.37 |
| 35. | Vengara | 0.006 | 0.05 | 0.31 | 0.20 | 1.56 |
| 36. | Kannapuram | 0.005 | 0.09 | 0.23 | 0.15 | 2.48 |
| 37. | Cheruthasham | 0.003 | 0.12 | 0.26 | 0.30 | 2.41 |
| 38. | Pallikkara | 0.006 | 0.09 | 0.43 | 0.30 | 1.85 |
| 39. | Pallikkara | 0.006 | 0.10 | 0.25 | 0.35 | 1.56 |
| 40. | Mattil | 0.008 | 0.12 | 0.29 | 0.28 | 1.62 |
| 41. | Kattukulam | 0.007 | 0.11 | 0.27 | 0.35 | 1.62 |
| 42. | Mundappuram | 0.008 | 0.16 | 0.25 | 0.40 | 1.56 |
| 43. | Thavom | 0.[illegible]04 | 0.19 | 0.24 | 0.28 | 1.69 |
| 44. | Chembellikundu | 0.005 | 0.11 | 0.27 | 0.20 | 0.40 |
| 45. | Cherukunnu | 0.005 | 0.12 | 0.30 | 0.45 | 1.69 |
| 46. | Kunnaru | 0.005 | 0.11 | 0.32 | 0.25 | 1.62 |
| 47. | Thuruthi | 0.007 | 0.08 | 0.25 | 0.18 | 0.41 |
| 48. | Eshom | 0.011 | 0.05 | 0.28 | 0.40 | 0.43 |
| 49. | Pinarai | 0.006 | 0.07 | 0.31 | 0.40 | 0.66 |
| 50. | Pashayangadi | 0.007 | 0.08 | 0.35 | 0.25 | 0.38 |
| 51. | Pashayangadi | 0.008 | 0.10 | 0.28 | 0.20 | 0.38 |
| 52. | Kunhimangalam | 0.010 | 0.13 | 0.34 | 0.20 | 0.31 |
| 53. | Ramanthali | 0.007 | 0.10 | 0.23 | 0.22 | 0.37 |
| 54. | Ramanthali | 0.006 | 0.15 | 0.22 | 0.43 | 0.59 |
| 55. | Eshimala | Tr | 0.16 | 0.19 | 0.39 | 1.44 |
| 56. | Eshimala | 0.002 | 0.16 | 0.20 | 0.43 | 0.53 |

11. <u>Aluminium oxide</u>

The range of values for the six profiles are respectively 1.38 to 5.73, 7.49 to 12.53, 3.28 to 11.42, 2.03 to 2.99, 2.69 to 5.43 and 2.20 to 4.43. The third horizon of Puthuvaippu shows the maximum value of 12.53 per cent and the third horizon of Vytilla profile reveals the least value of 1.38 per cent for $Al_2O_3$.

12. <u>Soil reaction</u>

In general, the profile samples in 1:2.5 soil-water suspension registered a pH varying from 3.4 to 6.4, 5.4 to 7.3, 3.1 to 3.2, 3 to 3.3, 2.8 to 5.1 and 5.4 to 7 for profiles 1 to 6 respectively. The third horizon of Vayalappra profile and the fourth layer of Puthuvaippu profile revealed the minimum value of 2.8 and the maximum value of 7.3 for pH. The pH of the surface samples from different locations vary between 3.0 and 7.0.

13. <u>Electrical conductivity</u>

The values of electrical conductivity in 1:2 soil-water suspension reveal no pattern. The values for EC range between 2.0 and 53.4 mmhos/cm. The EC of the surface samples vary from 3.9 to 37.3 mmhos/cm.

14. <u>Cation exchange capacity</u>

The CEC of the profile samples range from a minimum value of 4.3 me/100 g soil for sandy textured horizons to

Table-11. Aluminium oxides, iron oxides and sesquioxides of the profile samples

| Sample No. | Location | Depth (cm) | Profile No. | $Al_2O_3$ % | $Fe_2O_3$ % | $R_2O_3$ % |
|---|---|---|---|---|---|---|
| **Pokkali and Oramundakan** | | | | | | |
| 1. | Vytilla | 0-10 | 1 | 5.73 | 9.89 | 15.62 |
| 2. | | 10-30 | | 2.95 | 10.80 | 13.75 |
| 3. | | 30-53 | | 1.38 | 8.17 | 9.55 |
| 4. | | 53-79 | | 2.08 | 5.17 | 7.25 |
| 5. | Puthuvaippu | 0-5 | 2 | 9.97 | 11.31 | 21.28 |
| 6. | | 5-10 | | 7.49 | 11.26 | 18.75 |
| 7. | | 10-15 | | 12.53 | 8.50 | 21.03 |
| 8. | | 15-25 | | 8.76 | 7.99 | 16.75 |
| 9. | Cherai | 0-10 | 3 | 3.28 | 12.66 | 15.94 |
| 10. | | 10-15 | | 3.70 | 13.80 | 17.50 |
| 11. | | 15-35 | | 11.42 | 9.47 | 20.89 |
| 12. | Karunagapally | 0-28 | 4 | 2.99 | 0.52 | 3.51 |
| 13. | | 28-48 | | 2.38 | 0.37 | 2.75 |
| 14. | | 48-68 | | 2.03 | 0.29 | 2.32 |
| **Kaipad** | | | | | | |
| 15. | Vayalappra | 0-15 | 5 | 3.91 | 5.42 | 9.33 |
| 16. | | 15-30 | | 5.43 | 4.82 | 10.25 |
| 17. | | 30-60 | | 4.37 | 5.63 | 10.00 |
| 18. | | 60-110 | | 2.69 | 6.19 | 8.88 |
| 19. | Pallikkara | 0-25 | 6 | 3.73 | 7.52 | 11.25 |
| 20. | | 25-45 | | 4.43 | 6.45 | 10.88 |
| 21. | | 45-70 | | 2.54 | 4.55 | 7.09 |
| 22. | | 70-95 | | 2.20 | 7.31 | 9.51 |

40.8 me/100 g soil in the case of silty clay. The values for CEC show a decreasing trend in Karunagapally and Cherai profiles with increase in depth. In Vytilla profile a decreasing trend upto the third horizon followed by a slight increase. The Puthuvaippu profile exhibits a slight initial increase followed by a steady decrease with depth. No distinct pattern is observed in the Vayalappra and Pallikkara profiles. The CEC of the surface samples range between 8.8 and 31.7 me/100 g soil.

15. Exchangeable cations

(a) Sodium.

Fairly high values for exchangeable sodium are observed in the Puthuvaippu and Cherai profiles. When the Puthuvaippu and Pallikkara profiles reveal a decreasing trend with increase in depth the reverse is the trend for the Cherai and Vayalappra profiles. A general increasing trend with depth is noticed in the Vytilla profile. The surface samples from various locations recorded values for exchangeable sodium between 2.06 and 8.59 me/100 g soil. One of the surface samples from Puthuvaippu and another Vengara respectively show the maximum and minimum values for exchangeable sodium.

(b) Potassium.

Compared to other exchangeable cations the exchangeable potassium content of the profile samples are low. Moreover no clear cut pattern is visible in any of the profile under study.

Table-12(a). Chemical analysis of soils (profile samples)

| Sample No. | Location | Depth (cm) | Profile No. | pH (1:2.5) | E.C. (1:2) (mmhos/cm) | C.E.C. (me/100 g) | Exchangeable cations (me/100 g) Na | K | Ca | Mg | L.R. (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pokkali and Orumundakan** | | | | | | | | | | | |
| 1. | Vytilla | 0-10 | 1 | 4.6 | 5.5 | 14.5 | 3.0 | 0.8 | 1.1 | 5.2 | 1,400 |
| 2. | | 10-30 | | 5.7 | 2.0 | 12.2 | 2.3 | 0.9 | 1.6 | 5.1 | 840 |
| 3. | | 30-53 | | 6.4 | 2.2 | 12.4 | 2.7 | 1.5 | 1.2 | 5.8 | 500 |
| 4. | | 53-79 | | 3.4 | 5.1 | 17.4 | 3.2 | 0.3 | 1.6 | 4.6 | 14,000 |
| 5. | Puthuvaippu | 0-5 | 2 | 6.9 | 53.4 | 40.3 | 9.1 | 7.4 | 11.5 | 6.9 | 240 |
| 6. | | 5-10 | | 6.3 | 41.9 | 40.8 | 8.5 | 6.7 | 12.3 | 5.2 | 460 |
| 7. | | 10-15 | | 5.4 | 47.6 | 38.5 | 8.1 | 5.3 | 10.1 | 5.8 | 980 |
| 8. | | 15-25 | | 7.3 | 34.1 | 34.2 | 7.5 | 6.1 | 12.6 | 3.2 | - |
| 9. | Cherai | 0-10 | 3 | 3.2 | 29.6 | 20.1 | 4.2 | 0.4 | 4.1 | 6.6 | 9,720 |
| 10. | | 10-15 | | 3.1 | 28.2 | 18.9 | 5.6 | 0.2 | 5.8 | 4.1 | 11,000 |
| 11. | | 15-35 | | 3.2 | 31.3 | 18.2 | 5.9 | 0.6 | 4.7 | 4.4 | 7,560 |
| 12. | Karunagapally | 0-28 | 4 | 3.1 | 4.5 | 4.5 | 1.8 | Tr | Tr | 2.1 | 3,120 |
| 13. | | 28-48 | | 3.0 | 5.0 | 4.3 | 1.9 | Tr | Tr | 2.1 | 3,680 |
| 14. | | 48-66 | | 3.3 | 4.0 | 4.3 | 1.7 | Tr | Tr | 2.4 | 2,200 |
| **Kaipad** | | | | | | | | | | | |
| 15. | Vayalappra | 10-15 | 5 | 5.1 | 7.8 | 13.0 | 2.5 | 0.4 | 1.6 | 4.2 | 320 |
| 16. | | 15-30 | | 4.0 | 4.0 | 15.1 | 2.8 | 0.4 | 1.8 | 3.8 | 840 |
| 17. | | 30-60 | | 2.8 | 5.6 | 14.6 | 2.8 | 0.1 | 1.5 | 3.8 | 15,880 |
| 18. | | 60-110 | | 3.1 | 6.0 | 19.9 | 4.3 | 0.1 | 1.2 | 5.3 | 7,800 |
| 19. | Pallikkara | 0-25 | 6 | 6.9 | 14.3 | 15.8 | 4.0 | 0.9 | 1.9 | 6.4 | 80 |
| 20. | | 25-45 | | 7.0 | 5.6 | 13.6 | 3.4 | 1.3 | 1.3 | 4.0 | - |
| 21. | | 45-70 | | 6.7 | 6.1 | 12.9 | 3.4 | 1.1 | 1.4 | 5.6 | 150 |
| 22. | | 70-95 | | 5.4 | 5.8 | 13.7 | 2.9 | 0.9 | 1.8 | 3.3 | 720 |

The Vytilla and Pallikkara profiles exhibit an initial increase followed by a steady decrease and the Puthuvaippu profile shows a steady decrease upto the third horizon. The exchangeable potassium values vary from trace to 7.4 me/100 g soil. The Karunagapally profiles practically contains no exchangeable potassium. The exchangeable potassium content of the surface samples range from trace to 6.8 me/100 g and one of surface soil samples collected from Puthuvaippu reveals the highest exchangeable potassium content of 6.8 me/100 g

(c) Calcium

The exchangeable calcium vary from trace to 12.6 me/100 g soil. The maximum and minimum values here also observed in the Puthuvaippu and Karunagapally profiles respectively. No pattern is noticed in the vertical distribution of this element. The exchangeable calcium content of the surface samples range from 0.24 to 7.3 me/100 g soil. The surface samples from Puthuvaippu exhibit the maximum and the one from Thavom of Kaipad area shows the minimum value.

(d) Magnesium

The exchangeable magnesium content ranges between 2.1 and 6.9 me/100 g soil. Like sodium all profiles exhibit fairly high values for exchangeable magnesium also. An alternate decreasing and increasing pattern with depth is observed in the Vytilla, Puthuvaippu and Pallikkara profiles. The values for exchangeable magnesium remains more or less constant in

Table-12(b). Chemical analysis of soils (surface samples)

| Sample No. | Location | pH (1:2.5) | E.C. (1:2) (mmhos/cm) | C.E.C. (me/100 g) | Exchangeable cations (me/100 g) Na | K | Ca | Mg | L.R. (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| **Pokkali and Orumundakan** | | | | | | | | | |
| 23. | Madathilthara | 3.2 | 20.0 | 14.8 | 2.2 | 0.2 | 2.2 | 4.4 | 3,440 |
| 24. | Padanayar-kulangara | 3.0 | 14.4 | 15.7 | 2.8 | 0.1 | 1.5 | 6.2 | 3,720 |
| 25. | Chandakayal | 3.0 | 17.4 | 14.2 | 3.3 | Tr | 2.5 | 4.8 | 3,800 |
| 26. | Thodiyoor | 5.8 | 13.5 | 17.4 | 4.2 | Tr | 4.2 | 4.4 | 760 |
| 27. | Puthuvaippu | 7.0 | 30.4 | 28.4 | 7.6 | 6.8 | 7.3 | 3.2 | — |
| 28. | Puthuvaippu | 6.4 | 37.3 | 31.7 | 8.5 | 6.2 | 6.5 | 3.3 | 350 |
| 29. | Cherai | 3.2 | 32.8 | 16.8 | 4.4 | 0.2 | 3.7 | 5.3 | 7,400 |
| 30. | Thuravoor | 4.9 | 6.5 | 25.4 | 3.8 | 1.9 | 4.1 | 8.8 | 1,280 |
| **Kaipad** | | | | | | | | | |
| 31. | Vayalappra | 5.5 | 6.6 | 16.1 | 3.6 | 1.1 | 2.9 | 4.3 | 1,040 |
| 32. | Vayalappra | 5.2 | 23.2 | 14.5 | 2.7 | 1.1 | 2.6 | 3.7 | 890 |
| 33. | Vayalappra | 5.3 | 22.9 | 13.3 | 3.4 | 0.6 | 2.8 | 4.8 | 740 |
| 34. | Vengara | 5.3 | 8.2 | 13.6 | 4.2 | 0.9 | 3.0 | 3.4 | 680 |
| 35. | Vengara | 5.2 | 13.2 | 12.8 | 2.1 | Tr | 3.4 | 4.6 | 580 |
| 36. | Kannapuram | 4.2 | 39.2 | 15.0 | 4.7 | 0.3 | 2.9 | 5.6 | 860 |
| 37. | Cheruthazham | 4.9 | 23.7 | 16.4 | 3.9 | 0.6 | 1.2 | 7.6 | 1,040 |
| 38. | Pallikkara | 5.4 | 38.3 | 20.1 | 5.8 | 0.4 | 2.2 | 5.9 | 580 |
| 39. | Pallikkara | 5.4 | 19.8 | 22.7 | 4.2 | 0.3 | 3.9 | 5.7 | 580 |
| 40. | Mattil | 4.8 | 20.1 | 24.7 | 4.6 | 0.7 | 3.6 | 6.6 | 1,280 |
| 41. | Kattukulam | 6.0 | 23.1 | 21.3 | 5.8 | 1.2 | 0.9 | 6.3 | 270 |
| 42. | Mundappuram | 5.9 | 22.1 | 25.2 | 3.5 | 1.2 | 2.1 | 6.8 | 290 |
| 43. | Thavam | 5.4 | 29.1 | 12.8 | 3.5 | 0.9 | 0.2 | 7.4 | 320 |
| 44. | Chembellikundu | 7.0 | 6.9 | 13.5 | 4.2 | 0.5 | 1.5 | 4.2 | — |
| 45. | Cherukunnu | 5.1 | 29.6 | 16.6 | 6.3 | 0.5 | 1.6 | 4.8 | 2,040 |
| 46. | Kannara | 5.5 | 19.4 | 12.4 | 2.1 | 0.5 | 1.5 | 6.4 | 520 |
| 47. | Thuruthi | 6.7 | 7.8 | 12.2 | 3.1 | 0.5 | 2.2 | 5.7 | 140 |
| 48. | Ezhom | 6.1 | 4.8 | 14.8 | 3.1 | 1.6 | 2.3 | 5.5 | 420 |
| 49. | Pinarai | 5.9 | 6.3 | 15.8 | 4.8 | 1.4 | 2.4 | 6.2 | 320 |
| 50. | Pazhayangadi | 6.5 | 4.9 | 11.9 | 4.2 | 1.4 | 1.8 | 2.1 | 200 |
| 51. | Pazhayangadi | 7.0 | 4.6 | 9.6 | 2.4 | 0.7 | 1.8 | 3.7 | — |
| 52. | Kunhimangalam | 6.4 | 5.1 | 8.8 | 2.9 | 0.7 | 0.3 | 4.2 | 180 |
| 53. | Ramanthali | 6.9 | 3.9 | 13.2 | 4.1 | 0.8 | 2.5 | 3.2 | 100 |
| 54. | Ramanthali | 6.8 | 10.4 | 14.9 | 4.0 | 1.2 | 2.8 | 2.2 | 100 |
| 55. | Ezhimala | 7.0 | 7.8 | 19.0 | 4.7 | 1.5 | 1.9 | 5.6 | — |
| 56. | Ezhimala | 6.6 | 23.1 | 14.4 | 4.6 | 0.2 | 0.8 | 6.8 | 190 |

all the horizons of the Karunagapally profile. The Cherai profile shows an initial decrease followed by an increase with depth. The Vayalappra profile registers an initial decrease followed by a steady increase with depth. The exchangeable magnesium content of the surface samples range from 2.1 to 8.8 me/100 g soil. The surface sample of Thuravoor exhibits the maximum value and the surface sample of Pazhayangadi shows the least value for exchangeable magnesium.

16. Lime requirement (LR)

The lime requirement of profiles 1 to 6 vary from 500 to 14,000, 0 to 980, 7560 to 11,000, 2200 to 3680, 320 to 15,880 and 0 to 720 kg/ha., respectively. In general all the layers of Cherai profile require fairly high amounts of lime to raise its pH to 7.0 and the Pallikkara profile has the minimum requirement. In general the lime requirement of sub-surface horizons are higher than that of surface horizons. The third horizon of the Vayalappra profile ranks first with 15,880 kg/ha. The last horizon of Puthuvaippu and the second horizon of Pallikkara require no lime at all. The lime requirement of various surface soils range from 0 to 7400 kg/ha. The surface sample from Cherai has the maximum lime requirement (7400 kg/ha). Out of 34 surface samples only 14 require lime application at rates higher than 600 kg. of $CaCO_3$/ha.

C. COMPOSITION OF THE SATURATION EXTRACT

Table 13(a) and (b) present data on the $EC_e$, pH, cationic

Table-13(a). Analytical characteristics of the saturation extract of profile samples

| Sample No. | Location | Depth (cm) | Profile No. | SP | pH | E.C. (mmhos/cm) | Composition of the saturation extract in me/l: Na | K | Ca | Mg | Cl | $SO_4$ | KAR | SAR | ESP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pokkali and Orumundakan** | | | | | | | | | | | | | | | |
| 1. | Vytilla | 0-10 | 1 | 73 | 6.0 | 32.6 | 125.3 | 12.2 | 26.3 | 92.7 | 212.8 | 52.5 | 1.6 | 16.2 | 18.5 |
| 2. | | 10-30 | | 67 | 5.5 | 7.6 | 78.3 | 3.1 | 7.5 | 19.5 | 40.2 | 56.3 | 0.8 | 21.3 | 23.1 |
| 3. | | 30-53 | | 68 | 5.7 | 9.0 | 80.0 | 2.6 | 9.8 | 19.2 | 54.6 | 58.6 | 0.7 | 21.0 | 22.9 |
| 4. | | 53-79 | | 67 | 2.7 | 30.2 | 104.4 | 0.5 | 10.3 | 78.7 | 115.2 | 94.1 | 0.1 | 15.7 | 17.9 |
| 5. | Puthuvaippu | 0-5 | 2 | 105 | 5.2 | 226.3 | 591.5 | 43.5 | 95.0 | 573.0 | 1336.0 | 187.4 | 2.4 | 32.4 | 31.7 |
| 6. | | 5-10 | | 90 | 6.5 | 140.9 | 562.7 | 35.8 | 75.1 | 448.9 | 916.0 | 192.2 | 2.2 | 34.8 | 33.3 |
| 7. | | 10-15 | | 84 | 5.6 | 142.1 | 498.0 | 40.9 | 72.5 | 476.5 | 892.0 | 213.3 | 2.5 | 30.0 | 30.1 |
| 8. | | 15-25 | | 89 | 6.8 | 131.4 | 468.0 | 38.4 | 70.4 | 383.6 | 848.0 | 141.4 | 2.6 | 31.1 | 30.8 |
| 9. | Cherai | 0-10 | 3 | 90 | 3.2 | 138.8 | 382.9 | 2.5 | 43.5 | 455.4 | 584.0 | 217.3 | 0.2 | 24.7 | 26.0 |
| 10. | | 10-15 | | 93 | 2.9 | 108.3 | 370.0 | 1.5 | 46.5 | 472.0 | 671.0 | 230.4 | 0.1 | 22.8 | 24.5 |
| 11. | | 15-35 | | 94 | 3.4 | 91.8 | 372.3 | 7.2 | 57.2 | 485.8 | 768.0 | 178.2 | 0.4 | 22.6 | 24.3 |
| 12. | Karunagapally | 0-28 | 4 | 48 | 2.7 | 32.2 | 258.3 | 1.0 | 13.4 | 199.6 | 176.0 | 204.0 | 0.1 | 25.0 | 26.3 |
| 13. | | 28-48 | | 46 | 2.8 | 30.2 | 229.8 | Tr | 10.2 | 167.8 | 169.0 | 239.0 | - | 24.4 | 25.8 |
| 14. | | 48-68 | | 38 | 3.2 | 20.2 | 230.9 | Tr | 12.6 | 192.4 | 112.0 | 321.6 | - | 22.8 | 24.5 |
| **Kaipad** | | | | | | | | | | | | | | | |
| 15. | Vayalappra | 0-15 | 5 | 78 | 5.2 | 108.1 | 158.8 | 23.6 | 45.1 | 193.9 | 284.8 | 100.4 | 2.2 | 15.4 | 17.7 |
| 16. | | 15-30 | | 77 | 3.6 | 31.3 | 146.8 | 9.2 | 20.4 | 97.6 | 177.6 | 90.5 | 1.2 | 19.1 | 21.2 |
| 17. | | 30-60 | | 82 | 2.6 | 30.8 | 115.9 | 1.1 | 10.0 | 125.0 | 154.8 | 101.1 | 0.1 | 14.2 | 16.5 |
| 18. | | 60-110 | | 80 | 2.8 | 35.1 | 152.8 | 0.5 | 9.6 | 176.4 | 160.8 | 158.6 | 0.1 | 15.9 | 18.1 |
| 19. | Pallikkara | 0-25 | 6 | 79 | 4.8 | 72.1 | 204.2 | 15.4 | 36.6 | 185.4 | 364.0 | 92.4 | 1.5 | 19.4 | 21.5 |
| 20 | | 25-45 | | 86 | 6.1 | 31.5 | 173.8 | 10.2 | 17.4 | 121.6 | 222.0 | 113.1 | 1.2 | 20.8 | 22.8 |
| 21. | | 45-70 | | 89 | 5.9 | 29.4 | 173.3 | 8.7 | 18.0 | 119.0 | 202.8 | 102.4 | 1.1 | 20.9 | 22.9 |
| 22. | | 70-95 | | 90 | 5.4 | 31.8 | 143.0 | 11.3 | 21.9 | 105.1 | 160.8 | 142.7 | 1.4 | 17.9 | 20.1 |

and anionic composition of the saturation extract of the soil samples from various horizons of the 6 profiles and surface samples from the three distinct saline areas of the State.

1. pH and EC.

The results on the pH of the saturation extract brings out the variable nature of the active acidity in the soils under study. The pH of the saturation extract of the profile samples varies from 2.6 to 6.8, taking all the horizons of all the profiles into consideration. In the case of the surface soil samples the pH of the saturation extract is found to vary from 2.7 to 6.0. The pH of the saturation extract of all the horizons in the Cherai and Karunagapally profiles are below 3.5. In the Vayalappra profile the pH of the extract of the surface horizon is 5.2, but there is an abrupt and steady decrease to 3.6 and subsequently to 3.8. In the Puthuvaippu and Pallikkara profile however, there is a general increase in pH with depth and this increase takes place in two steps viz., initial increase followed by a decrease and then again an increase. In the Vytilla profile a decrease of pH of the saturation extract from 6 to 2.7 happens below a depth of 53 cm.

The pH of the saturation extract of the surface samples collected from Pokkali and Orumundakan areas varies from 3 to 5.1 and the maximum value exhibited by the Thuravoor sample.

Table-13(b). Analytical characteristics of the saturation extract of the surface samples

| Sample No. | Location | SP | pH | $EC_e$ (mmhos/cm) | Composition of the saturation extract in me/l: Na | K | Ca | Mg | Cl | $SO_4$ | KAR | SAR | ESP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pokkali and Orumundakan** | | | | | | | | | | | | | |
| 23. | Madathilthara | 24 | 3.8 | 100.2 | 387.0 | 9.2 | 47.8 | 431.2 | 684.0 | 200.8 | 0.6 | 25.0 | 26.3 |
| 24. | Padanayar-kulangara | 33 | 3.0 | 73.7 | 384.6 | 1.0 | 44.3 | 307.7 | 464.0 | 281.7 | 0.1 | 28.9 | 29.3 |
| 25. | Chandakayal | 34 | 3.4 | 93.9 | 356.6 | Tr | 45.8 | 337.2 | 632.0 | 138.1 | - | 25.7 | 26.8 |
| 26. | Thodiyoor | 18 | 3.4 | 91.8 | 302.6 | 2.1 | 25.4 | 257.5 | 499.2 | 152.3 | 0.2 | 24.2 | 25.6 |
| 27. | Puthuvaippu | 106 | 4.3 | 100.7 | 301.6 | 7.9 | 62.2 | 328.8 | 716.8 | 173.9 | 2.6 | 21.5 | 23.3 |
| 28. | Puthuvaippu | 95 | 4.8 | 139.9 | 272.5 | 31.5 | 54.0 | 272.0 | 692.8 | 148.7 | 2.6 | 21.5 | 23.0 |
| 29. | Cherai | 87 | 3.2 | 102.6 | 302.8 | 5.1 | 47.2 | 357.8 | 641.6 | 106.0 | 0.4 | 21.3 | 23.2 |
| 30. | Thuravoor | 135 | 5.1 | 30.5 | 134.8 | 9.3 | 22.8 | 92.2 | 206.4 | 59.1 | 1.2 | 17.0 | 19.3 |
| **Kaipad** | | | | | | | | | | | | | |
| 31. | Vayalappra | 92 | 6.2 | 29.9 | 99.2 | 20.5 | 19.3 | 57.7 | 163.2 | 60.5 | 3.3 | 15.9 | 18.2 |
| 32. | Vayalappra | 81 | 4.7 | 109.7 | 152.1 | 12.3 | 59.4 | 351.6 | 170.4 | 342.7 | 0.9 | 12.2 | 14.3 |
| 33. | Vayalappra | 82 | 5.7 | 108.9 | 156.6 | 21.5 | 45.4 | 203.6 | 172.8 | 276.3 | 1.9 | 14.0 | 16.3 |
| 34. | Vengara | 90 | 3.6 | 50.4 | 123.5 | 13.3 | 25.4 | 109.6 | 189.6 | 94.0 | 1.6 | 15.0 | 17.3 |
| 35. | Vengara | 63 | 4.8 | 133.5 | 167.2 | 25.6 | 47.0 | 226.0 | 204.4 | 258.2 | 2.2 | 14.3 | 16.6 |
| 36. | Kannapuram | 39 | 4.4 | 198.7 | 374.1 | 40.9 | 65.2 | 304.8 | 618.0 | 199.5 | 3.0 | 27.5 | 28.3 |
| 37. | Cheruthazham | 90 | 5.5 | 154.8 | 174.0 | 30.7 | 52.2 | 243.8 | 231.6 | 266.1 | 2.5 | 14.2 | 16.4 |
| 38. | Pallikkara | 85 | 5.3 | 154.6 | 177.5 | 30.7 | 56.4 | 284.6 | 277.0 | 239.4 | 2.4 | 13.6 | 15.8 |

(Table-13(b) continued)

(Table-13(b) continued)

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| Sample No. | Location | SP | pH | $EC_e$ (mmhos/cm) | Composition of the saturation extract in me/l: Na | K | Ca | Mg | Cl | $SO_4$ | KAR | SAR | ESP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39. | Pallikkara | 87 | 6.3 | 147.3 | 174.0 | 26.6 | 56.0 | 274.0 | 270.8 | 240.6 | 2.1 | 13.6 | 15.8 |
| 40. | Muttil | 87 | 5.7 | 118.7 | 163.5 | 18.4 | 51.4 | 235.3 | 230.4 | 158.2 | 2.5 | 13.4 | 15.6 |
| 41. | Kattukulam | 89 | 5.8 | 113.0 | 125.3 | 16.4 | 48.7 | 182.3 | 264.4 | 106.0 | 1.5 | 11.7 | 13.7 |
| 42. | Mundappuram | 90 | 6.7 | 108.1 | 160.1 | 23.1 | 51.5 | 187.5 | 256.8 | 187.9 | 2.1 | 14.6 | 16.9 |
| 43. | Thavom | 87 | 5.9 | 88.3 | 120.1 | 13.3 | 36.4 | 128.6 | 177.6 | 114.4 | 1.5 | 13.2 | 15.4 |
| 44. | Chembellikundu | 85 | 6.8 | 56.2 | 123.5 | 10.2 | 31.1 | 63.9 | 181.2 | 53.8 | 1.5 | 11.1 | 13.1 |
| 45. | Cherukunnu | 94 | 6.7 | 52.5 | 132.2 | 12.3 | 27.6 | 83.4 | 158.8 | 91.2 | 1.6 | 17.7 | 19.9 |
| 46. | Kannara | 82 | 6.1 | 22.5 | 106.1 | 9.3 | 14.3 | 46.7 | 127.2 | 51.6 | 1.7 | 19.2 | 21.3 |
| 47. | Thuruthi | 90 | 6.9 | 63.1 | 134.7 | 17.4 | 29.3 | 99.7 | 220.8 | 81.0 | 2.2 | 16.8 | 19.0 |
| 48. | Ezhom | 91 | 7.2 | 20.1 | 111.4 | 10.2 | 16.2 | 38.8 | 142.8 | 15.0 | 1.9 | 21.2 | 23.1 |
| 49. | Pinarai | 88 | 6.2 | 38.4 | 116.6 | 12.3 | 21.0 | 77.0 | 158.8 | 61.2 | 1.8 | 16.7 | 18.9 |
| 50. | Pashayangadi | 89 | 6.6 | 28.6 | 106.1 | 11.3 | 28.5 | 72.5 | 150.0 | 70.2 | 1.6 | 14.9 | 17.2 |
| 51. | Pashayangadi | 82 | 6.9 | 27.3 | 111.4 | 10.2 | 32.3 | 56.7 | 170.4 | 49.5 | 1.5 | 16.7 | 18.9 |
| 52. | Kunhimangalam | 85 | 6.6 | 29.9 | 121.8 | 12.2 | 20.6 | 70.4 | 213.6 | 24.1 | 1.8 | 18.1 | 20.2 |
| 53. | Ramanthali | 81 | 6.9 | 38.4 | 118.3 | 13.3 | 18.6 | 74.4 | 193.2 | 28.4 | 1.9 | 17.3 | 19.6 |
| 54. | Ramanthali | 93 | 6.6 | 30.3 | 109.6 | 11.5 | 23.6 | 75.3 | 187.2 | 50.9 | 1.6 | 15.6 | 17.8 |
| 55. | Ezhimala | 90 | 6.8 | 62.5 | 135.7 | 13.4 | 27.2 | 23.8 | 282.0 | 8.6 | 1.9 | 19.1 | 21.2 |
| 56. | Ezhimala | 96 | 5.9 | 172.2 | 378.5 | 33.4 | 65.8 | 284.2 | 774.0 | 11.1 | 2.5 | 28.6 | 29.1 |

The pH of the Kaipad samples ranges between 3.6 and 7.2. It is significant to note that the electrical conductivity of the saturation extract ($EC_e$) varies from 7.6 to 226.3 mmhos/cm. The surface samples of Puthuvaippu, Cherai, Vayalappra and Pallikkara profiles have an electrical conductivity ranging from 72.1 to 226.3 mmhos/cm. The Vytilla and Karunagapally profiles representing the Pokkali and Orumundakan areas have an electrical conductivity for the saturation extract ($EC_e$) of the surface soil of about 32 mmhos/cm. In general with depth there is a consistent decrease in the $EC_e$ in all the profiles. However, in the Vytilla, Vayalappra and Pallikkara profiles there is a slight increase in the $EC_e$ from the third to fourth layer.

The $EC_e$ of the surface samples collected from various locations ranges between 20.1 and 198.7 mmhos/cm. It is significant to note that the maximum and minimum values exhibited by the surface samples belong to Kaipad area.

2. Cations

(a) Sodium.

The concentration of sodium varies from 78.3 to 591.5 me/l. Puthuvaippu, Cherai, Karunagapally and Pallikkara profiles record a sodium concentration in the saturation extract ranging from 591.5 to 143 me/l. In all these profiles there is either a slight decrease with depth or remains more or less steady with depth. In Vytilla profile there is a steady decrease with depth upto the third horizon beyond which there is a slight increase. A similar trend is noticed in the Vayalappra profile also.

The sodium status of the surface samples of Pokkali and Orumundakan lands varies from 134.8 to 387.0 me/l and that of the Kaipad areas from 99.2 to 378.5 me/l.

(b) Potassium

The potassium contents of the saturation extract of the various horizons of the profiles ranges from 43.5 me/l to trace. It is significant to note that the saturation extract of all the horizons of the Puthuvaippu profile record a potassium content significantly higher than that of the soils from other locations. The pattern of depthwise changes in the concentration of potassium, however, is slightly different from that of sodium in all the profiles except the Vytilla and Vayalappra profiles where a steady decrease with depth is observed.

The potassium content in the saturation extract of the surface samples of the three locations ranges from 37.9 me/l to trace. It is significant to note that the Pokkali and Kaipad lands are fairly well supplied with potassium.

(c) Calcium

The calcium values of the saturation extract range between 7.5 and 95.0 me/l. There is no close relationship between the pH of the saturation extract and the calcium concentration in the saturation extract. The calcium concentration however, has a general decreasing trend with depth in all the profiles, except the Cherai profile, where slight increasing trend with depth is observed. The calcium content of the surface samples varies from 14.3 to 65.8 me/l. Both the maximum and minimum values are observed in the surface samples from two locations in the Kaipad area.

(d) Magnesium.

The magnesium content of the saturation extract varies between 19.2 and 573.0 me/l. High values of magnesium are observed for the soils of the Puthuvaippu and Cherai profiles (in the ranges of 383.6 and 573.0 me/l) and medium values in the Karunagapally, Vayalappra and Pallikkara profiles (in the ranges of 97.6 and 199.6 me/l) and fairly low values for the Vytilla profile. It is also pertinent to point out the fact that the saturation extract contain generally a magnesium content 2 to 16 times more than that of the calcium concentration.

The Mg content in the saturation extracts of the surface samples varies between 38.8 and 431.2 me/l. The maximum and minimum values are represented by the samples from the Orumundakan and Kaipad areas respectively. Comparatively the magnesium content of the Pokkali and Orumundakan lands are higher than that of Kaipad areas.

2. Anions

Chloride and sulphate

The chloride content varies from 40.2 to 1336.0 me/l. In general the variation in chloride content closely parallels the variation in the sodium content in the saturation extract. Comparatively high chloride contents are observed in the Puthuvaippu, Cherai and Pallikkara profiles. The Vytilla, Karunagapally and Vayalappra profiles, however, have a much lower chloride content both in the surface and sub-surface horizons. In Puthuvaippu, Karunagapally and Pallikkara Profiles a steady decrease with increase in depth is observed. The chloride content of the surface samples vary from 127.2 to 774.0 me/l. Compared to Kaipad areas, the Pokkali and Orumundakan lands have a higher chloride content.

The sulphate status range between 52.5 to 321.6 me/l. The sulphate content on the other hand closely parallels the pH of the saturation extract, higher values being observed in soils with lower pH values. Higher sulphate contents are observed in Puthuvaippu, Cherai and Karunagapally profiles and moderate levels in Vytilla, Vayalappra and Pallikkara profiles. A steady increasing trend with increase in depth is observed in Vytilla and Karunagapally profiles.

The sulphate content of the surface samples range between 8.6 and 342.7 me/l. Both the maximum and minimum values are recorded from the surface samples of Kaipad lands. In general, a more or less uniform distribution of sulphate is noticed in the surface samples of the three locations.

4. (a) Sodium Adsorption Ratio (SAR)

The SAR values range between 14.2 and 34.8. The SAR values of the surface soils of the profiles vary from 15.4 to

Table-14. Seasonal variation in pH, EC, Na, K, Ca+Mg, Cl and $SO_4$ content of the saturation extract of the soil samples of Vytilla Research Station (Pokkali) Ernakulam district.

| Sample No. | | pH | | $EC_e$ (mmhos/cm) | | me/l | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Na | | K | | Ca+Mg | | Cl | | $SO_4$ | |
| | | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit |
| | **1976** | | | | | | | | | | | | | | |
| $S_1$ | April-1 | 3.7 | 3.5 | 19.6 | 5.8 | 190.4 | 93.8 | 7.8 | 4.2 | 110.0 | 34.6 | 280.6 | 99.0 | 39.4 | 20.3 |
| $S_2$ | April-2 | 3.6 | 4.7 | 24.9 | 9.3 | 214.9 | 84.3 | 9.1 | 1.9 | 90.0 | 40.0 | 285.4 | 92.4 | 32.0 | 19.3 |
| $S_3$ | May-1 | 4.5 | 5.8 | 13.4 | 11.2 | 152.4 | 136.0 | 4.2 | 1.9 | 86.4 | 56.9 | 176.1 | 96.2 | 76.4 | 64.5 |
| $S_4$ | May-2 | 3.8 | 4.8 | 10.0 | 8.6 | 133.4 | 103.2 | 3.9 | 1.3 | 72.6 | 48.3 | 148.3 | 90.6 | 48.5 | 40.0 |
| $S_5$ | June-1 | 4.3 | 6.1 | 5.5 | 9.2 | 73.7 | 60.7 | 2.6 | 1.3 | 24.5 | 42.5 | 74.8 | 80.1 | 34.5 | 24.5 |
| $S_6$ | June-2 | 4.8 | 4.6 | 18.2 | 15.0 | 173.6 | 173.6 | 6.5 | 2.8 | 82.0 | 65.0 | 253.4 | 237.8 | 19.5 | 19.5 |
| $S_7$ | July-1 | 7.0 | 5.7 | 1.8 | 13.7 | 18.6 | 108.5 | 1.3 | 5.2 | 41.5 | 45.0 | 56.7 | 140.5 | 7.5 | 2.9 |
| $S_8$ | July-2 | 6.1 | 3.8 | 1.8 | 9.4 | 14.2 | 184.6 | 1.9 | - | 30.0 | 60.0 | 36.7 | 188.2 | 6.8 | 72.5 |
| $S_9$ | August-1 | 3.0 | 2.8 | 6.4 | 5.7 | 98.8 | 95.1 | 1.3 | - | 45.0 | 61.5 | 72.1 | 62.5 | 70.0 | 87.8 |
| $S_{10}$ | August-2 | 4.1 | 4.8 | 6.1 | 4.7 | 99.8 | 78.1 | 2.6 | 1.9 | 26.0 | 44.5 | 56.1 | 54.3 | 62.0 | 50.4 |
| $S_{11}$ | September-1 | 6.0 | 6.5 | 3.4 | 3.7 | 56.4 | 34.7 | 2.6 | 0.6 | 18.5 | 28.0 | 52.5 | 23.5 | 17.5 | 32.0 |
| $S_{12}$ | September-2 | 6.5 | 5.7 | 6.3 | 4.7 | 46.8 | 86.8 | 2.6 | 2.6 | 31.5 | 28.5 | 50.0 | 29.9 | 18.0 | 62.0 |

(Table-14 continued)

| Sample No. | | pH | | $EC_e$ (mmhos/cm) | | me/l | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Na | | K | | Ca + Mg | | Cl | | $SO_4$ | |
| | | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit |
| $S_{13}$ | October-1 | 5.5 | 5.5 | 4.7 | 6.3 | 36.7 | 40.1 | 1.9 | - | 30.0 | 52.5 | 35.4 | 44.0 | 18.6 | 47.5 |
| $S_{14}$ | October-2 | 5.8 | 5.4 | 3.4 | 4.6 | 29.7 | 54.3 | 0.6 | 1.3 | 37.5 | 29.5 | 30.8 | 29.2 | 22.0 | 54.5 |
| $S_{15}$ | November-1 | 6.1 | 5.2 | 3.2 | 3.4 | 29.1 | 37.7 | 1.3 | 1.3 | 19.0 | 21.5 | 32.0 | 30.8 | 24.5 | 13.0 |
| $S_{16}$ | November-2 | 5.8 | 4.9 | 5.3 | 4.8 | 34.7 | 49.4 | 2.6 | 1.3 | 38.5 | 20.5 | 33.9 | 45.5 | 36.5 | 17.6 |
| $S_{17}$ | December-1 | 5.9 | 5.1 | 5.8 | 4.2 | 33.7 | 43.4 | 1.3 | - | 30.5 | 24.0 | 47.2 | 36.4 | 19.5 | 15.5 |
| $S_{18}$ | December-2 | 6.5 | 6.8 | 3.3 | 2.9 | 52.1 | 49.2 | 1.3 | - | 32.0 | 42.5 | 33.4 | 30.8 | 54.5 | 62.0 |
| | **1977** | | | | | | | | | | | | | | |
| $S_{19}$ | January-1 | 4.8 | 5.3 | 4.9 | 3.5 | 78.1 | 52.1 | 2.6 | 2.6 | 24.5 | 43.5 | 64.8 | 63.4 | 29.1 | 35.2 |
| $S_{20}$ | January-2 | 4.8 | 5.7 | 5.6 | 4.3 | 82.8 | 54.0 | 1.9 | 1.3 | 26.5 | 33.5 | 68.6 | 57.1 | 27.0 | 22.0 |
| $S_{21}$ | February-1 | 5.3 | 6.3 | 10.1 | 5.0 | 113.2 | 69.4 | 3.6 | 1.4 | 64.5 | 32.5 | 146.2 | 85.4 | 14.5 | 17.0 |
| $S_{22}$ | February-2 | 5.2 | 6.1 | 16.4 | 2.1 | 133.8 | 52.1 | 2.6 | 1.9 | 59.5 | 52.5 | 168.4 | 25.0 | 13.8 | 74.5 |
| $S_{23}$ | March-1 | 6.1 | 7.2 | 9.8 | 12.3 | 122.8 | 151.9 | 3.3 | 3.9 | 30.0 | 45.5 | 129.3 | 139.3 | 23.5 | 55.0 |
| $S_{24}$ | March-2 | 4.4 | 5.5 | 16.3 | 6.1 | 164.9 | 104.2 | 5.2 | 3.1 | 55.5 | 45.5 | 186.1 | 117.0 | 22.0 | 33.5 |

1 = 15th of each month

2 = 30th of each month

32.4. The changes in the SAR values with depth is observed to be different in various profiles. There is a steady decrease in the SAR values in the Cherai and Karunagapally profiles with depth. The SAR values of the surface samples of various locations ranged from 11.1 to 28.9.

(b) Potassium Adsorption Ratio (KAR)

The KAR values range between 0 to 2.5. In general KAR values decreases with depth in all the profiles except Puthuvaippu and Pallikkara profiles wherein a slight decrease followed by an increase is observed with depth. The KAR values of the surface samples varies from 0 to 3.3. Surface samples from Kaipad shows fairly uniform values.

5. Exchangeable Sodium Percentage (ESP)

The exchangeable sodium percentage of the soil at saturation ranges between 17.7 and 33.3. Thus in all the cases it is more than 15 per cent but however, this is at the time of collection viz., the peak season of salinity hazard (the months of February and March). The ESP values of the surface samples collected from the various locations of the three soil types varies from 13.1 to 29.3. The surface samples from Pokkali and Orumundakan lands show ESP values above 19 at the time of collection of samples.

6. Saturation percentage (SP)

Saturation percentage of the profile samples range from 38 to 103 per cent and that of the surface samples from 18 to 106 per cent.

Table-15. Seasonal variation in pH, EC, Na, K, Ca + Mg, Cl and $SO_4$ content of the saturation extract of the soil samples of Payyanur (Kaipad), Cannanore district.

| Sample No. | Month | pH | | EC (mmhos/cm) | | me/1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Na | | K | | Ca + Mg | | Cl | | $SO_4$ | |
| | | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit |
| | 1976 | | | | | | | | | | | | | | |
| $S_{25}$ | April-1 | 4.3 | 4.6 | 2.6 | 2.1 | 50.3 | 43.4 | 1.3 | - | 55.0 | 70.2 | 128.1 | 76.3 | 39.5 | 27.0 |
| $S_{26}$ | April-2 | 4.6 | 5.2 | 4.0 | 3.1 | 76.4 | 74.1 | - | - | 60.2 | 30.8 | 116.2 | 63.2 | 40.3 | 24.0 |
| $S_{27}$ | May-1 | 5.6 | 5.8 | 3.2 | 2.4 | 80.2 | 73.4 | - | - | 15.2 | 10.3 | 62.1 | 56.2 | 28.4 | 31.5 |
| $S_{28}$ | May-2 | 6.2 | 5.6 | 2.1 | 1.3 | 38.2 | 29.1 | - | - | 45.0 | 45.0 | 36.9 | 27.3 | 27.5 | 52.0 |
| $S_{29}$ | June-1 | 4.3 | 3.9 | 0.9 | 1.9 | 30.1 | 49.0 | - | - | 30.0 | 10.0 | 26.1 | 32.8 | 49.5 | 49.5 |
| $S_{30}$ | June-2 | 2.9 | 2.7 | 1.2 | 1.4 | 23.4 | 34.7 | - | - | 45.5 | 50.0 | 27.8 | 37.8 | 34.5 | 35.5 |
| $S_{31}$ | July-1 | 3.5 | 3.1 | 2.5 | 9.0 | 16.5 | 36.0 | - | - | 35.0 | 30.0 | 18.8 | 29.0 | 23.5 | 39.4 |
| $S_{32}$ | July-2 | 3.8 | 3.5 | 0.2 | 0.5 | 6.3 | 12.2 | - | - | 10.5 | 10.5 | 16.3 | 24.2 | 4.8 | 29.5 |
| $S_{33}$ | August-1 | 3.6 | 3.0 | 0.3 | 12.4 | 3.2 | 42.2 | - | - | 35.5 | 99.5 | 15.2 | 33.4 | 35.5 | 112.0 |
| $S_{34}$ | August-2 | 3.6 | 3.8 | 2.4 | 8.2 | 12.2 | 56.0 | - | - | 50.0 | 77.0 | 26.6 | 31.4 | 29.5 | 83.2 |
| $S_{35}$ | September-1 | 3.3 | 4.0 | 3.8 | 2.4 | 15.9 | 32.4 | - | - | 55.0 | 35.5 | 24.5 | 17.6 | 42.0 | 64.5 |
| $S_{36}$ | September-2 | 3.1 | 4.1 | 1.4 | 2.8 | 24.2 | 54.2 | - | - | 45.0 | 30.0 | 29.0 | 39.7 | 49.5 | 42.0 |
| $S_{37}$ | October-1 | 4.2 | 4.3 | 2.1 | 2.5 | 24.3 | 39.2 | - | - | 50.0 | 15.0 | 28.0 | 19.4 | 48.0 | 45.0 |
| $S_{38}$ | October-2 | 5.0 | 4.0 | 1.9 | 8.2 | 44.3 | 136.2 | - | - | 45.5 | 25.0 | 53.2 | 114.7 | 39.5 | 29.5 |

(Table-15 continued)

(Table-15 continued

-2-)

| Sample No. | Month | pH | | $EC_e$ | | me/l | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Na | | K | | Ca+Mg | | Cl | | $SO_4$ | |
| | | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit | Mound | Pit |
| $S_{39}$ | November-1 | 7.3 | 6.5 | 2.4 | 2.0 | 23.8 | 17.4 | - | - | 50.0 | 35.0 | 17.4 | 21.1 | 62.0 | 36.5 |
| $S_{40}$ | November-2 | 7.3 | 5.7 | 0.5 | 0.5 | 10.8 | 14.2 | - | - | 15.0 | 60.5 | 14.9 | 22.0 | 11.5 | 57.0 |
| $S_{41}$ | December-1 | 4.3 | 4.5 | 0.2 | 1.3 | 15.6 | 10.3 | - | - | 40.0 | 55.5 | 18.5 | 26.8 | 44.5 | 44.5 |
| $S_{42}$ | December-2 | 4.4 | 4.5 | 1.1 | 1.5 | 17.4 | 12.8 | - | - | 40.5 | 65.5 | 15.5 | 24.6 | 33.5 | 53.5 |
| | <u>1977</u> | | | | | | | | | | | | | | |
| $S_{43}$ | January-1 | 5.1 | 3.8 | 0.5 | 1.8 | 15.9 | 16.5 | - | - | 65.0 | 40.5 | 42.2 | 14.3 | 27.0 | 62.0 |
| $S_{44}$ | January-2 | 4.2 | 6.8 | 1.1 | 0.7 | 17.4 | 20.8 | - | - | 60.0 | 46.0 | 37.8 | 27.2 | 39.5 | 36.0 |
| $S_{45}$ | February-1 | 4.2 | 6.9 | 2.9 | 1.8 | 41.2 | 34.7 | - | - | 39.5 | 40.0 | 46.6 | 36.7 | 29.5 | 32.0 |
| $S_{46}$ | February-2 | 4.4 | 4.5 | 2.4 | 2.9 | 47.7 | 50.7 | - | 1.3 | 40.0 | 42.5 | 36.0 | 56.1 | 45.5 | 45.5 |
| $S_{47}$ | March-1 | 4.2 | 4.8 | 2.2 | 8.5 | 52.1 | 92.3 | 2.6 | 1.3 | 49.0 | 54.5 | 38.4 | 72.2 | 54.8 | 69.5 |
| $S_{48}$ | March-2 | 3.1 | 4.2 | 3.1 | 12.4 | 63.0 | 156.5 | 1.3 | 3.9 | 33.5 | 65.5 | 57.5 | 164.8 | 40.5 | 52.5 |

1 = 15th of each month

2 = 30th of each month

D. SEASONAL VARIATION IN SALINITY

1. (a) Pokkali

Table-14 presents data on the seasonal variation in pH, EC, cationic and anionic concentration of the saturation extract of the soil samples collected at fortnightly intervals from April 1976 to March 1977 from Vytilla (Pokkali) Research Station, Ernakulam.

pH.

There is a general increase in pH of the mound samples from the months of April to December, followed by a decreasing trend upto January, and again an increasing trend till the middle of March. There is an increase in the pH of the pit samples upto the month of June, a gradual decrease till August followed again by an increase which remains fairly steady till February-March. The pH of the mound samples are lower than the pH of the pit samples, till June. They become nearly the same by the middle of June and subsequently the pH of the pit samples decrease to a lower value till August beyond which the pH of the mounds and pits are fairly the same till the end of October. After October the pH of the pit samples is slightly below that of the mounds till the beginning of December. From December the pH of the pit samples is found to be higher than the corresponding mound samples.

Table-16. Seasonal variation in pH, $EC_e$, Na, K, Ca + Mg, Cl and $SO_4$ content of the saturation extract of the soil samples of Karunagapally (Orumundakan) Quilon district.

| Sample No. | Month | pH | $EC_e$ (mmhos/cm) | Na (me/l) | K (me/l) | Ca+Mg (me/l) | Cl (me/l) | $SO_4$ (me/l) |
|---|---|---|---|---|---|---|---|---|
| | **1976** | | | | | | | |
| $S_{49}$ | April-1 | 2.7 | 28.3 | 238.5 | 7.8 | 326.1 | 437.2 | 102.4 |
| $S_{50}$ | April-2 | 2.5 | 23.0 | 226.4 | 8.3 | 320.0 | 421.8 | 97.0 |
| $S_{51}$ | May-1 | 2.5 | 19.2 | 216.8 | 2.6 | 510.5 | 680.3 | 34.5 |
| $S_{52}$ | May-2 | 3.4 | 21.9 | 264.7 | 1.3 | 320.0 | 336.0 | 116.5 |
| $S_{53}$ | June-1 | 2.8 | 19.9 | 225.6 | Tr | 290.5 | 236.0 | 264.0 |
| $S_{54}$ | June-2 | 2.6 | 12.7 | 214.0 | Tr | 108.0 | 139.9 | 154.5 |
| $S_{55}$ | July-1 | 2.6 | 25.1 | 234.3 | 1.9 | 200.5 | 284.3 | 152.0 |
| $S_{56}$ | July-2 | 2.6 | 20.1 | 164.9 | 1.3 | 85.0 | 100.2 | 139.5 |
| $S_{57}$ | August-1 | 2.6 | 19.8 | 147.4 | 1.3 | 160.5 | 271.3 | 96.0 |
| $S_{58}$ | August-2 | 2.5 | 19.6 | 225.7 | 2.6 | 156.0 | 212.8 | 67.5 |
| $S_{59}$ | September-1 | 2.5 | 14.8 | 126.0 | 1.9 | 144.5 | 188.5 | 58.4 |
| $S_{60}$ | September-2 | 2.8 | 16.1 | 220.4 | 2.6 | 160.5 | 332.0 | 33.5 |
| $S_{61}$ | October-1 | 3.0 | 17.3 | 132.4 | 2.6 | 151.4 | 248.0 | 46.5 |
| $S_{62}$ | October-2 | 2.8 | 13.1 | 188.6 | 1.3 | 82.1 | 194.8 | 62.0 |
| $S_{63}$ | November-1 | 3.3 | 12.9 | 165.5 | 1.9 | 68.3 | 143.4 | 76.5 |
| $S_{64}$ | November-2 | 2.6 | 15.6 | 120.4 | Tr | 81.5 | 136.2 | 52.5 |
| $S_{65}$ | December-1 | 2.6 | 21.1 | 182.9 | Tr | 96.0 | 164.0 | 114.5 |
| $S_{66}$ | December-2 | 2.5 | 30.8 | 264.1 | Tr | 290.3 | 354.5 | 190.0 |
| | **1977** | | | | | | | |
| $S_{67}$ | January-1 | 2.7 | 38.0 | 320.9 | 1.3 | 342.0 | 510.9 | 172.0 |
| $S_{68}$ | January-2 | 2.6 | 32.7 | 299.3 | 2.6 | 304.5 | 495.0 | 152.5 |
| $S_{69}$ | February-1 | 3.2 | 46.2 | 364.0 | 8.3 | 348.6 | 564.0 | 132.5 |
| $S_{70}$ | February-2 | 3.0 | 39.6 | 288.2 | 7.8 | 308.2 | 488.5 | 144.5 |
| $S_{71}$ | March-1 | 3.2 | 61.4 | 378.7 | 5.2 | 351.8 | 691.3 | 70.0 |
| $S_{72}$ | March-2 | 3.1 | 54.2 | 395.4 | 11.6 | 392.4 | 684.3 | 126.5 |

1 = 15th of each month
2 = 30th of each month

<u>$EC_e$</u>

The electrical conductivity of the saturation extract ($EC_e$) shows variation with period and also with location of the sample. The $EC_e$ of the mound samples is fairly high in the month of April. This decreases from May to significantly low values in July and August. However by the second week of June, there has been an increase in the $EC_e$ of the samples which is a deviation from the general pattern. The decline of $EC_e$ continues till the month of December, after which there is a progressive increase of the $EC_e$ of the mound samples. From April to June-July, there is a general increase in the $EC_e$ of the pit samples. Beyond August there is a general decline upto February, beyond which an increase is observed. Comparing the pattern of changes in $EC_e$ between mound and pit samples from corresponding locations the mound samples have a higher $EC_e$ than the pit samples from April to the end of May. From June to the end of July, the mound samples have a much lower value. From August to December there is not much difference between the mound and the pit samples, but from January the mound samples have a higher $EC_e$.

The Na, K, Ca + Mg, Cl and $SO_4$ concentrations of the saturation extract also closely parallel the data on the electrical conductivity.

(b) <u>Kaipad.</u>

Table 15 presents data on the seasonal variation in pH, $EC_e$, cationic and anionic composition of the saturation extract.

Table 17. Seasonal fluctuations in pH, EC, Cl and $SO_4$ of water samples of Vytilla Research Station, (Pokkali) Ernakulam District.

| Sample No. | Month<br>1976 | pH | E.C. (mmhos/cm) | Cl (me/l) | $SO_4$ (me/l) | Rainfall (mm) |
|---|---|---|---|---|---|---|
| $W_1$ | April-1 | 4.5 | 16.2 | 297.4 | 24.1 | 59.5 |
| $W_2$ | April-2 | 4.8 | 15.6 | 282.0 | 32.6 | |
| $W_3$ | May-1 | 5.2 | 14.4 | 264.2 | 8.3 | 82.2 |
| $W_4$ | May-2 | 6.1 | 13.3 | 204.6 | 8.2 | |
| $W_5$ | June-1 | 4.2 | 10.5 | 180.4 | 10.4 | 168.3 |
| $W_6$ | June-2 | 3.3 | 8.5 | 176.0 | 14.6 | |
| $W_7$ | July-1 | 3.9 | 3.9 | 74.8 | 25.5 | 763.5 |
| $W_8$ | July-2 | 4.9 | 0.6 | 66.0 | 43.0 | |
| $W_9$ | August-1 | 7.8 | 2.4 | 52.8 | 10.5 | 311.5 |
| $W_{10}$ | August-2 | 6.8 | 1.3 | 48.4 | 27.6 | |
| $W_{11}$ | September-1 | 7.6 | 1.3 | 48.4 | 35.6 | 136.1 |
| $W_{12}$ | September-2 | 7.9 | 1.3 | 38.8 | 70.3 | |
| $W_{13}$ | October-1 | 8.1 | 2.1 | 57.2 | 30.5 | 295.5 |
| $W_{14}$ | October-2 | 7.5 | 1.8 | 66.0 | 20.8 | |
| $W_{15}$ | November-1 | 7.3 | 0.6 | 44.0 | 44.5 | 396.0 |
| $W_{16}$ | November-2 | 8.5 | 1.5 | 57.2 | 23.2 | |
| $W_{17}$ | December-1 | 8.4 | 1.4 | 66.8 | 10.6 | 3.0 |
| $W_{18}$ | December-2 | 8.6 | 1.4 | 70.4 | 8.3 | |
| | 1977 | | | | | |
| $W_{19}$ | January-1 | 8.4 | 3.7 | 79.2 | 14.5 | Nil |
| $W_{20}$ | January-2 | 7.1 | 6.4 | 114.4 | 15.5 | |
| $W_{21}$ | February-1 | 7.5 | 8.2 | 154.0 | 25.5 | 0.6 |
| $W_{22}$ | February-2 | 4.5 | 8.2 | 160.2 | 28.7 | |
| $W_{23}$ | March-1 | 7.3 | 9.8 | 167.2 | 12.6 | 79.9 |
| $W_{24}$ | March-2 | 5.4 | 13.0 | 233.2 | 13.3 | |

(Rainfall data source - Indian Meteorological Department, Trivandrum)

1 - 15th of each month
2 - 30th of each month

The soils were collected periodically at fortnightly intervals from the mounds and pits in the same field for about an year.

pH

The data on pH show that from April to May there is an initial increase in pH, followed by a slight decrease in August-September, then an increase till November, beyond which a further decrease. Between the mound and pit samples, the pH of the mound samples are lower than that of the pit samples for the two months of April and May. Subsequently the pit samples are found to be more acidic till the end of August. In October-November, December and early part of January the mound samples are either having the same pH as the pit samples or a slightly higher pH. In February and March the pH of the mound samples are definitely lower than the corresponding pit samples.

$EC_e$

The electrical conductivity of the saturation extract ($EC_e$) of the mound samples gradually decreases to a value of 0.2 mmhos/cm by July-August and later increases gradually. By November-December it again falls back to 0.2 mmhos/cm and then increases gradually to 3.0 mmhos/cm by March. In the pit samples a gradual decrease to a minimum value of 0.5 mmhos/cm by July, and a gradual increase to values higher than corresponding mound samples is observed till the month of October. By November it again attains a minimum value of 0.5 mmhos/cm, showing a

Table-18. Seasonal fluctuations in pH, EC, Cl and $SO_4$ of water samples of Payyannur, (Kaipad) Cannanore District.

| Sample No. | Month | pH | E.C. (mmhos/cm) | Cl (me/1) | $SO_4$ (me/1) | Rainfall (mm) |
|---|---|---|---|---|---|---|
| | 1976 | | | | | |
| $W_{25}$ | April-1 | 5.5 | 33.6 | 504.6 | 50.5 | 35 |
| $W_{26}$ | April-2 | 7.4 | 38.2 | 584.4 | 105.0 | |
| $W_{27}$ | May-1 | 8.5 | 25.3 | 347.6 | 43.8 | 52 |
| $W_{28}$ | May-2 | 7.6 | 16.7 | 242.0 | 10.5 | |
| $W_{29}$ | June-1 | 7.3 | 14.8 | 220.0 | 27.6 | 448 |
| $W_{30}$ | June-2 | 6.1 | 0.5 | 70.4 | 35.4 | |
| $W_{31}$ | July-1 | 6.1 | 0.4 | 57.2 | 70.3 | 1184 |
| $W_{32}$ | July-2 | 7.0 | 0.2 | 44.0 | 30.5 | |
| $W_{33}$ | August-1 | 7.5 | 0.5 | 61.6 | 20.1 | 343 |
| $W_{34}$ | August-2 | 7.4 | 0.3 | 48.4 | 42.5 | |
| $W_{35}$ | September-1 | 6.9 | 0.9 | 44.0 | 23.2 | 110 |
| $W_{36}$ | September-2 | 7.3 | 5.2 | 128.0 | 10.6 | |
| $W_{37}$ | October-1 | 7.4 | 1.0 | 61.6 | 8.3 | 98 |
| $W_{38}$ | October-2 | 7.7 | 10.1 | 242.0 | 4.5 | |
| $W_{39}$ | November-1 | 7.8 | 7.9 | 248.3 | 15.5 | 243 |
| $W_{40}$ | November-2 | 7.3 | 0.9 | 49.4 | 25.7 | |
| $W_{41}$ | December-1 | 6.4 | 1.3 | 70.4 | 2.7 | 10 |
| $W_{42}$ | December-2 | 7.7 | 30.3 | 383.6 | 28.3 | |
| | 1977 | | | | | |
| $W_{43}$ | January-1 | 8.4 | 23.2 | 374.0 | 3.3 | Nil |
| $W_{44}$ | January-2 | 8.7 | 21.2 | 281.6 | 25.1 | |
| $W_{45}$ | February-1 | 8.4 | 12.4 | 177.2 | 33.0 | Nil |
| $W_{46}$ | February-2 | 8.4 | 13.2 | 184.8 | 12.3 | |
| $W_{47}$ | March-1 | 8.8 | 29.8 | 409.2 | 29.5 | Nil |
| $W_{48}$ | March-2 | 8.4 | 32.2 | 442.4 | 18.6 | |

(Rainfall data source - State Seed Farm, Kankole, Payyanur)

1 = 15th of each month
2 = 30th of each month

steady trend to increase by March. Comparing the mound and pit samples in respect to $EC_e$, it is seen that the mound samples have a higher $EC_e$ than the corresponding pit samples till May, beyond which the reverse is the situation till January. By the end of January the mound samples have a higher $EC_e$ which, however, gets reversed again by March.

The cationic and anionic composition represented by Na, K, Ca + Mg, Cl and $SO_4$ respectively show the similar variation with period as shown by electrical conductivity of the saturation extract.

(c) <u>Orumundakan</u>

Table-16 presents data on the seasonal variation in pH, $EC_e$, cationic and anionic concentrations of the saturation extract of the surface soil samples.

<u>pH.</u>

The pH of the soils are below 3.0 throughout the period except in May, November, February and March, when it shows a tendency to increase.

<u>$EC_e$</u>

The electrical conductivity of the saturation extract ($EC_e$) shows a decrease with progressive leaching by the monsoon rains. By the middle of November it attains a value nearly half of that recorded in April and beyond November it increases. The same pattern is observed for the cationic and anionic composition of the saturation extract of the soil samples.

Table-19. Seasonal fluctuations in pH, EC, Cl and $SO_4$ of water samples of Karunagapally, (Orumundakan) Quilon district.

| Sample No. | Month | pH | EC (mmhos/cl) | Cl (me/l) | $SO_4$ (me/l) | Rainfall (mm) |
|---|---|---|---|---|---|---|
| | **1976** | | | | | |
| $W_{49}$ | April-1 | 3.4 | 0.6 | 67.2 | 45.2 | 321.6 |
| $W_{50}$ | April-2 | 3.0 | 0.8 | 52.6 | 61.8 | |
| $W_{51}$ | May-1 | 6.8 | 0.5 | 50.4 | 55.5 | 191.2 |
| $W_{52}$ | May-2 | 7.1 | 1.5 | 81.2 | 78.7 | |
| $W_{53}$ | June-1 | 3.1 | 2.6 | 52.8 | 92.5 | 179.7 |
| $W_{54}$ | June-2 | 6.3 | 3.8 | 79.2 | 92.3 | |
| $W_{55}$ | July-1 | 3.6 | 0.7 | 59.6 | 42.9 | 349.0 |
| $W_{56}$ | July-2 | 2.6 | 0.4 | 44.2 | 59.5 | |
| $W_{57}$ | August-1 | 3.1 | 3.2 | 82.8 | 34.6 | 145.0 |
| $W_{58}$ | August-2 | 6.8 | 2.5 | 68.4 | 54.5 | |
| $W_{59}$ | September-1 | 7.0 | 2.4 | 65.2 | 47.2 | 97.0 |
| $W_{60}$ | September-2 | 7.3 | 1.4 | 44.0 | 72.0 | |
| $W_{61}$ | October-1 | 6.8 | 0.9 | 57.2 | 89.3 | 192.0 |
| $W_{62}$ | October-2 | 7.0 | 0.4 | 46.8 | 92.5 | |
| $W_{63}$ | November-1 | 3.4 | 0.6 | 44.1 | 70.4 | 320.0 |
| $W_{64}$ | November-2 | 3.6 | 0.9 | 61.6 | 85.2 | |
| $W_{65}$ | December-1 | 7.3 | 3.6 | 72.5 | 32.2 | 78.0 |
| $W_{66}$ | December-2 | 7.1 | 4.2 | 96.8 | 34.7 | |
| | **1977** | | | | | |
| $W_{67}$ | January-1 | 2.6 | 9.5 | 124.6 | 70.3 | Nil |
| $W_{68}$ | January-2 | 2.9 | 8.4 | 154.0 | 56.5 | |
| $W_{69}$ | February-1 | 2.5 | 12.3 | 166.5 | 48.0 | 16.0 |
| $W_{70}$ | February-2 | 2.9 | 10.3 | 114.0 | 59.3 | |
| $W_{71}$ | March-1 | 3.1 | 12.7 | 170.4 | 42.3 | 27.0 |
| $W_{72}$ | March-2 | 3.0 | 7.4 | 138.1 | 39.5 | |

(Rainfall data source - Indian Meteorological Department, Trivandrum)

1 = 15th of each month
2 = 30th of each month

2. Seasonal fluctuations in salinity of surface water samples

Table 17, 18 and 19 present data on seasonal changes in pH, electrical conductivity, chloride and sulphate content of surface water samples collected at fortnightly intervals from April 1976 to March 1977 from 3 locations viz., Vytilla (Pokkali), Payyanur (Kaipad) and Karunagapally (Orumundakan) respectively. The total rainfall received in each month is also included in the table.

Vytilla.

The surface water pH is acidic during the period from March to July beyond which it rises to values above 6.8 except in the period between the second half of February to the 2nd half of March 1977. The electrical conductivity of the surface water gets reduced to 0.6 mmhos/cm by the middle of November and later it gradually increase to 13 mmhos/cm by March.

Payyanur.

The seasonal fluctuation in the water samples from Payyanur record a decrease in salinity from 33.0 in April to 0.2 mmhos/cm by the end of July and later increases to 32.2 mmhos/cm by March in the subsequent year.

Karunagapally.

In the case of the Orumundakan area the electrical conductivity of the surface water samples show an erratic trend of increase and decrease at fortnightly intervals. However, the general tendency is to decrease from April to October and increase subsequently.

Rainfall.

The monthly averages of the rainfall received in the three locations for the period from 1960 to 1975 and also for the year 1976 are given in Appendix I to III. From the data it can be seen that the period from February 1976 to March 1977 is probably one of the most peculiar years with respect to failure of both the monsoons. During the period of sampling the monthwise as well as the total rainfall received is found to be less than the monthwise and total averages for the previous 16 years.

# DISCUSSION

## DISCUSSION

An investigation on the morphological, physical, physico-chemical and chemical properties including salinity aspects of three types of coastal saline soils viz., Pokkali, Kaipad and Orumundakan have been conducted by undertaking detailed studies on six profiles and thirty four surface samples from representative areas of each of the three types. Seasonal variation in salinity levels on the samples of soils from three marked locations representing these three types, were also studied at fortnightly intervals from April 1976 to March 1977 in relation to the composition of surface waters from the same fields. The results of these investigations are discussed not only from the point of view of compiling basic data for classifying these soils but also for suggesting modifications to the existing methods of management of these soils in the context of total food production. The rainfall data of all the three locations have also been taken into consideration.

Morphological features of the profiles

The morphological description of the six profiles together with a brief description of each profile is given in Tables 1 to 6 under materials and methods and the locations of the surface samples under study are indicated in the tables presenting relevant data regarding them. As has been mentioned earlier in the introduction, the Pokkali, Kaipad and Orumundakan soils are situated along the coastal regions in the districts of Ernakulam, Cannanore, Alleppey and Quilon respectively. Vayalappra (Profile No.5) and Pallikkara (Profile No.6) represent typical Kaipad areas situated respectively on the flood banks of the rivers Ramapuram and Pazhayangadi and 3 to 4 km east of the coast. The Vytilla profile (No.1) was dug up in plot number 19 of the Rice Research Station, Vytilla (Kerala Agricultural University) situated on the flood banks of Pennurunni puzha at a short distance upstream from a point where it joins the Vembanad lake. The Puthuvaippu (Profile No.2) is situated north of Vypeen and surrounded on three sides by the sea and linked to the main land through the Ochenthuruthu-Puthuvaippu road. The Cherai profile (No.3) representing Pokkali areas is situated north-east of Puthuvaippu adjoining Narakkal. Puthuvaippu was specially selected in view of its geological and agricultural importance. This area of 3 to 5 sq.kilometers has been formed as a result of geological upheaval or silting up of the sea about 25 years back and the only cultivation in the area at present is coconut. During 1976 it has been reported that cultivation with paddy has been attempted by some of the settlers in the area, by taking raised beds as is practiced in some areas under Pokkali and Kaipad. The Karunagapally profile (No.4) is located in a field 300 meters away from the Chandakayal and 4 km west of the national high way.

In all these situations the soils have been formed either under lacustrine or alluvial conditions, and the profiles are flooded for 6 to 8 months in a year with brackish water. The water table can be reached within 10 to 110 cm in the summer season in all of them. The features of the horizons are described in Table 1 to 6 under Materials and Methods.

<u>Classification of soils according to the Seventh Approximation</u>

<u>Profiles from Vytilla, Puthuvaippu and Cherai (Nos.1, 2 & 3).</u>

These are mineral soils with less than five per cent organic matter. Except for an epipedon no diagnostic horizons are present. The texture is finer than loamy fine sand (clay loam to clay). The sodium saturation exceeds 15 per cent in all the horizons of all the three profiles at the peak summer season, but calcic, gypsic and plinthitic horizons are absent. In view of this, they can be placed in the Order-Entisol.

The soils described by profiles 1, 2 and 3 are permanently saturated with water and have dominant hues when dry (10 YR, 5 Y and 5 Y) and moist (7.5 YR, 5 Y and 5 Y). The chromas range from 0 to 2. Mottlings are of frequent occurrence in profile 1 and absent in 2 and 3. These characteristics enable us to place them in Sub order-Aquents.

The soils of these profiles experience warm summer and winter temperatures but differ by more than 5°C. The nitrogen values are less than 0.5 per cent (Average values - 0.05, 0.07 and 0.06 respectively for profiles 1 to 3) between 22 to 50 cm depth. The texture is fine and becomes finer below Ap epipedon. The profiles 1 to 3 show very slight differences in Chromas.

These characteristics enable us to group them under the Great group and sub groups viz., Haplaquents and Aeric Haplaquents respectively.

Profile from Karunagapally (No.4).

Mineral soil lacking diagnostic horizons except an agric epipedon. The organic matter content is less than 3 per cent. The sodium saturation is above 15 per cent in the peak salinity season of summer. These soils possess a coarse texture. These characteristics enable us to include it under the Order Entisol.

The texture is coarser in all parts of the profile and have no mineral fragments in the diagnostic horizons. These soils are not permanently saturated with water and lack the characteristics of Aquents. These characteristics enable to the profile included in the Sub order Psamments.

The soils have a warm temperature above 8°C. Lack an albic horizon at the surface. The ground water level is reached within 1 meter of the surface for 6 months or more in most of the years. The soils lack sufficient iron to turn red on ignition. These properties enable us to include these soils in the Great group of Quartzi Psamments and under the Sub group Aquodic Quartzi Psamments.

Profiles from Vavalappore and Pallikkara (Nos. 5 & 6).

Mineral soils with less than 3 per cent organic matter and saturated with water in some periods of the year. The texture is finer than loamy fine sand (Sand clay loam). Have dominant hues when dry (5 YR and 10 YR) and moist (10 YR & 10 YR).

An agric epipedon is present. These attributes enable them to be included in the Order Entisols.

Organic matter decreases irregularly but is above 0.35 per cent. These soils have a mean annual soil temperature above $0^{o}C$ ($25^{o}$). Saturated with water in some parts of the year. Occur in nearly flat terrain. These characteristics enable us to place them in the Sub order Fluvents.

The soils are usually moist but dry for 90 cumulative days or more in most years in sub-horizons between 18-50 cm but are not continuously dry in all sub horizons between these depths. The mean annual soil temperature is above $25^{o}C$. Have a horizon within 1 meter from the surface, more than 15 cm thick, that contains durinodes that are brittle and of firm consistence when moist. The soils cracks in summer. These attributes enable us to place them under the Great group Ustifluvents and in the Sub group Durorthidic Ustifluvents.

Physical characteristics.

Data on the mechanical composition and textural classification of the profile samples indicate that all the horizons fall between the two extreme textural groups of silty clay and sand. The surface soils of the six profiles are clay loam, silty clay, sand, sandy loam and sandy clay loam. Except for the Cherai and Pallikkara profiles where with an increase in depth there is an increase in clay content, in none of the other profiles is the change in the soil separates large enough to shift the textural group of the soil. Thus the horizon differentiation is to be justified more on the basis of other properties of the soil like colour and salinity levels than on the textural differentiation. The finer fractions represented by silt plus clay is more than 80 per cent in all the horizons of the Pathuvaippu profile. None of the other profiles have such a significant quantity of finer fractions in any of their horizons. Further, when finer fractions are considered it is found that there is a decrease in their content with depth in the Vytilla, Vayalappra and Karunagapally profiles and an increase in the Cherai and Pallikkara profiles. In the former group of profiles lateral migration of the finer fractions brought about by flood waters appears to have played a dominant role in the formation of the profile features, while in the Cherai and Pallikkara profiles migration of finer fractions from surface to sub-surface layers is indicated. The increasing finer fraction content in the lower horizons of the Cherai and Pallikkara profiles suggest that the leaching and drainage of these soils which is a basic requirement for their management is likely to be more difficult.

A steady decrease in the absolute specific gravity is observed in the Cherai and Karunagapally profiles. In the same profile we notice an increase in sand fraction with depth, and in other profiles no clear cut pattern with respect to apparent specific gravity is noticed. In the Vytilla and Cherai profiles a decreasing trend with increasing depth and in the Vayalappra profile an initial decrease followed by a general increase is observed. A general trend to increase pore space with depth is observed in the three profiles viz., Vytilla, Puthuvaippu, Vayalappra and Pallikkara. The maximum water holding capacity is also found to increase with depth in the Cherai and Pallikkara profiles. The maximum volume expansion is noticed in a surface sample from Thuravoor with the highest organic matter content of 6.35 per cent.

Chemical constituents.

No regular pattern is observed in the distribution of the organic carbon in the profile samples. The Puthuvaippu, Vayalappra and Pallikkara profiles show a general increasing trend with depth while in the other profiles it is fairly steady. The organic carbon content of the surface samples taken from various locations range between 0.12 and 3.69 per cent. This points to the high degree of variability observed in the chemical composition of the saline soils of the State. In conformity with the data on organic carbon it is seen that the total nitrogen status does not vary much with depth in the profile samples. In general, the total nitrogen content varies between 0.008 and 0.084 in the profiles and 0.011 to 0.109 in the surface samples collected from various locations. Thus there are soils which are fairly well supplied with nitrogen as well as those which are very poor with respect to this nutrient. This being particularly true with the sandy soils of the Orumundakan and Kaipad regions.

The total phosphorus content is found to be deficient in all the locations of the Pokkali, Orumundakan and Kaipad areas and range between trace and 0.009 per cent except in the recently formed soils of Puthuvaippu, which record a phosphorus content of 0.02 per cent. It is interesting to compare these results to the more intensively studied saline kayal soils of Kuttanad which have been recorded to contain much higher levels of phosphorus (Kurup, 1967 and Menon, 1975). The total calcium and magnesium are found to vary in both the profile and surface samples between 0.03 to 0.34 and 0.13 to 0.88 per cent respectively. Comparing these values with the saline kayal soils of Kuttanad, it is seen that these soils contain comparatively higher content of magnesium and a much lower amount of calcium. It has to be emphasised that saline soils included in the present study do not contain any lime shells and are inundated by sea water more frequently than the reclaimed lake-bed soils (Kayal soils) of Kuttanad. Sodium and potassium contents are much higher in these soils than in other paddy soils of the State. This is mainly due to the continuous submergence with salt water for more than 6 to 8 months and the frequent inundation by brackish waters due to tidal effect even during the rest of the year.

The total sesquioxide content show varying values. Thus the Puthuvaippu and Karunagapally profiles have the highest and lowest values respectively. In the Cherai profile the sesquioxide content increases with depth while the reverse is the case in the Vytilla and Karunagapally profiles. In respect of both the total sesquioxides and aluminium oxide the highest values are recorded in the Puthuvaippu profile. This only brings out the widely varying conditions under which these alluvial and lacustrine soils are formed. The wide difference in the hydrological conditions of the profiles viz., the depth of the ground water level in the summer months and the depth upto which drying takes place in summer vary from profile to profile due to these differences in hydrology. Consequently the differential oxidation and reduction of iron differs markedly in the various horizons bringing about alterations in their content at various horizons.

In all the profiles the CEC closely follow the clay and organic matter content. Significant positive correlations for both these factors are observed ( $r = +0.824$ and $+0.848$). Menon (1975) established a similar positive correlation ($r = +0.82$) between organic matter and CEC, in the midly saline soils viz., the Kayal soils of Kuttanad. The CEC values for the profile samples and surface samples range from 4.3 to 40.8 and 3.8 to 31.7 me/100 g. The high CEC of the Puthuvaippu and Cherai soils and the low CEC of the Karunagapally soils can thus be attributed to the high content of clay and organic matter in the former and the poor content of both these constituents in the latter.

It has been observed that Na and Mg are the dominant exchangeable cations and the values for Na and Mg respectively range from 1.7 to 9.1 and 2.1 to 8.8 me/100 g. Menon (1975) reported fairly high values for these cations in the Kayal soils of Kuttanad. The results of the present study further emphasises the dominance of these cations in the salt affected soils of the State, which are under frequent intrusion by the brackish waters from adjoining lakes or sea.

The surface samples of all the profiles have a pH ranging from 3.1 to 6.9. A significant negative correlation is observed between the pH and sulphate content (r = -0.532). A similar negative correlation was established by Nair and Money (1972) while studying the salt affected soils of Kerala. A similar negative correlation exists between pH and chloride (r = -0.461). Out of the 40 surface samples, including the six surface samples of the profiles studied 19 have a, pH below 5.5, 11 have a pH ranging between 5.5 and 6.5 and the remaining 10 samples have a pH above 6.5. Thus about 50 percent of the samples studied are highly acidic. The lime requirement of the soils were also studied and 13 samples had a lime requirement value found ranging between 0 and 15,880 kg/ha; 6 samples required no lime application, 18 required lime application below 500 kg and 12 required lime application between half ton and one ton. Twelve samples had a lime requirement value between 1 ton and 5 tons and 7 soils above 5 tons. It is also interesting to note that these soils which require high doses of lime record low pH values for their saturation extract revealing the high degree of active and potential acidity present in them. Similar acid sulphate saline soils are found in the Senegal delta (Durand, 1969). From these results it is clear that use of soil amendments are also required coupled with leaching of soluble salts. Thus some of the soils with high lime requirement are possibly of the acid sulphate type similar to some of the highly acid soils of the Kuttanad and Kole region, requiring heavy application of soluble liming materials. The lime application will have to restricted to the mounds to keep down the dosage to economic levels and necessarily coupled with leaching to remove both soluble salts and the exchanged $H^{+}$ and $Al^{+++}$ ions. The levels of lime and the extent of leaching given will have to be worked out under field conditions as a continuation of this study. Some of them require heavy doses of liming materials, others require medium doses while some soils require only leaching. The problems relating to optimising rice yields in these soils cannot be solved by breeding and using high yielding saline resistant varieties alone. Since the magnitude of salinity and acidity are location specific, soil management studies will have to be conducted as multi-locational trials to arrive at economic methods of cultivation.

Composition of the saturation extract.

In order to assess the degree of salinity in the profile as well as the surface samples, detailed chemical studies were

Table-20. Correlation values

| No. | Particulars | r |
|---|---|---|
| 1. | Clay x ESP | +0.522** |
| 2. | Clay x SAR | +0.553** |
| 3. | Clay x CEC | +0.848** |
| 4. | Organic matter x ESP | +0.62** |
| 5. | Organic matter x CEC | +0.824** |
| 6. | Organic matter x SAR | +0.645** |
| 7. | pH x Conductivity | -0.388* |
| 8. | pH x Chloride | -0.461** |
| 9. | pH x Sulphate | -0.532** |
| 10. | Conductivity x Chloride | +0.711** |
| 11. | Conductivity x $SO_4$ | +0.58** |

**Significant at 1% level

*Significant at 5% level

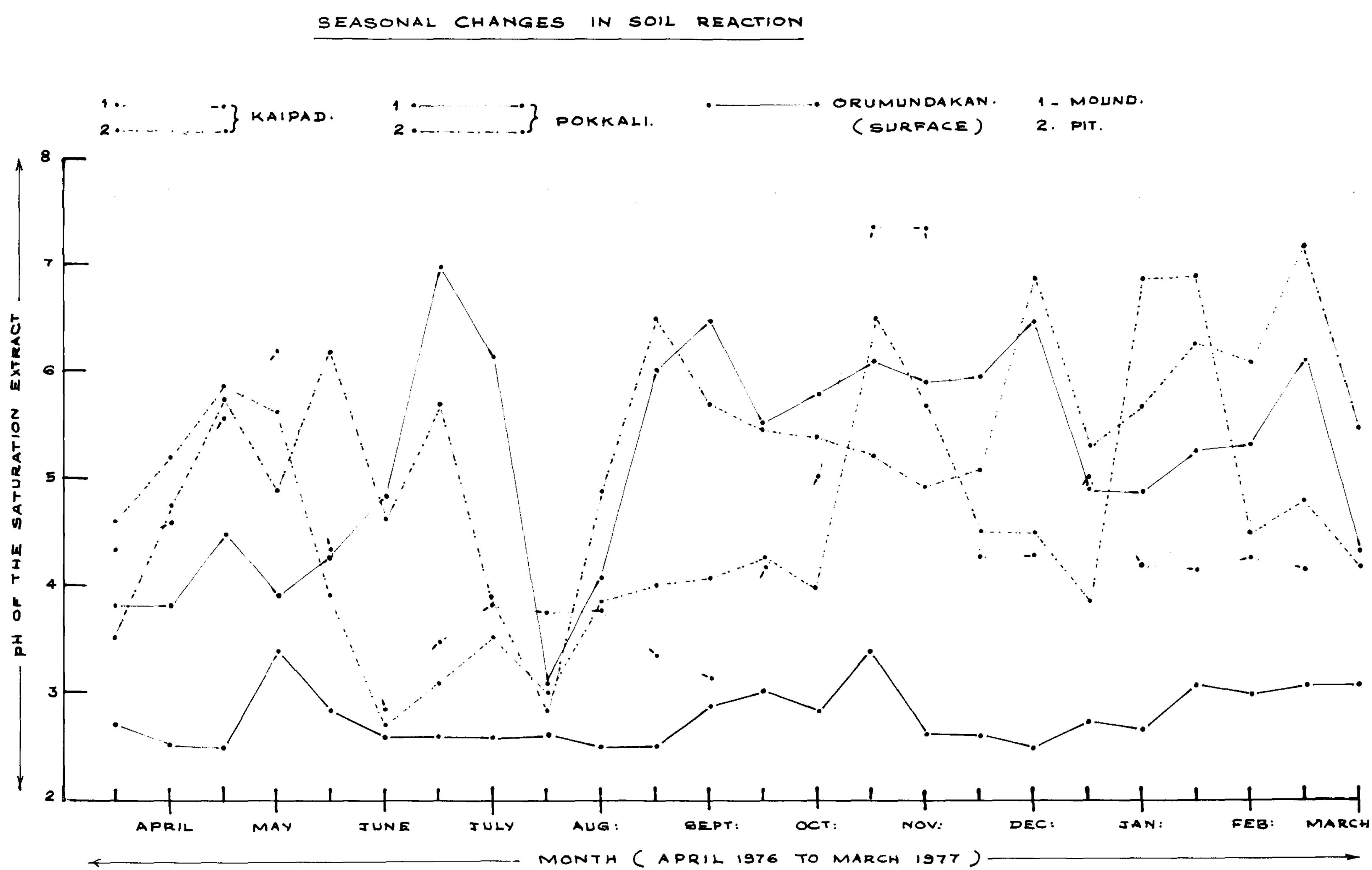
conducted on the saturation extract. The electrical conductivity of the saturation extract of the profile samples reveal that the levels of conductivity are very high in the surface samples in the months of February-March. A significant positive correlation is observed between conductivity and chloride ($r = +0.711$) and a similar interrelation is found between conductivity and sulphate ($r = +0.58$). Further, the pH of the saturation extracts are below 7.0, this lends further support to the view that these saline soils are of the chloride-sulphate type. The magnitude of soluble salts present in these soils in the summer months is as high as 226.3 mmhos/cm and as low as 7.6 mmhos/cm. Even the comparatively low values recorded are above the critical limits recognised for rice seedlings in the earlier stages of growth. It is interesting to note that among the Pokkali soils studied the soils of Vytilla are having the minimum content of soluble salts, even in summer. Thus the problems of salinity encountered in the Rice Research Station, Vytilla, are comparatively of lesser magnitude than in other tracts of the Pokkali, Kaipad and Orumundakan lands. The profile samples collected from the 6 locations of the saline areas reveal different patterns for the levels of soluble salt content in the various horizons. In general, there is a consistent decrease in the $EC_e$ with depth. In the Vytilla, Vayalappra and Pallikkara profiles, however, there is a slight increase in the $EC_e$ from the third to the fourth layer.

In such locations, where the lower layers have higher salinity than the surface layers, capillary rise of water in the summer months may contribute towards the salinity levels in the surface layers besides periodical inundation from adjoining brackish waters. This possibility cannot be overruled, since the capillary rise of chloride is known to be quicker and greater than that of sulphate (Fattakh, 1966). According to Elgabaly and Naguib (1965) in highly saline soils the depth of ground water is a more important contributing factor to the soil salinity in the surface layers and the salinity of the sub-soil in turn is also affected by cropping and irrigation regimes. During the rainy season the entire profile is saturated with water and downward leaching will be taking place. The higher salinity levels encountered in the lower horizons besides tending to increase the salinity in the cultivated horizons by capillary ascent in the summer months may also retard or slow down the leaching process during the subsequent monsoon period. In view of this, studies on the fluctuation of the ground water level and composition of the ground water in summer months may have to be taken up by sinking piezometers in future programmes of study.

The concentration of sodium varies from 78.3 to 591.5 me/l in the saturation extract. In both the profiles and the surface samples the Na concentration closely parallels the conductivity values of the corresponding saturation extracts, showing thereby that Na compounds are the predominent salts in the soil. The chloride concentration is much higher than the sulphate concentration suggesting thereby that NaCl is the major soluble salt in the soil. The content of both sodium and chloride increases with decreasing distance from the coast (Surface sample of Profile 2, and samples 28 and 27 in the order). Subramaniam et al. (1976) studied the coastal tract soils of Bengal and obtained similar results. The findings of the present study corraborates the findings of Elsokkary et al. (1978). They investigated the effect of sea water intrusion on the soil salinity status of the Sammania project in the northern coastal area of Egypt and observed that both in the soil and ground water Na and Cl were the predominant ions present. The saturation extracts in the present study are found to contain 2 to 16 times more Mg than Ca. The greater abundance of Mg is due to the marine influence. From the data on cation and anion composition of the soil extracts it is evident that these soils are of the Na-Mg-Ca-K type which is the usual type encountered in the coastal saline soils elsewhere also (Bhargava, 1977). Based on the anion content, the soils are found to be the Cl-$SO_4$ type. Thus the soils of the typical saline areas of Kerala viz., Pokkali, Kaipad and Orumundakan are of the Na-Mg-Cl-$SO_4$ type.

The potassium content in the saturation extract range from trace to 43.5 me/l in both the profile and surface

FIGURE 1

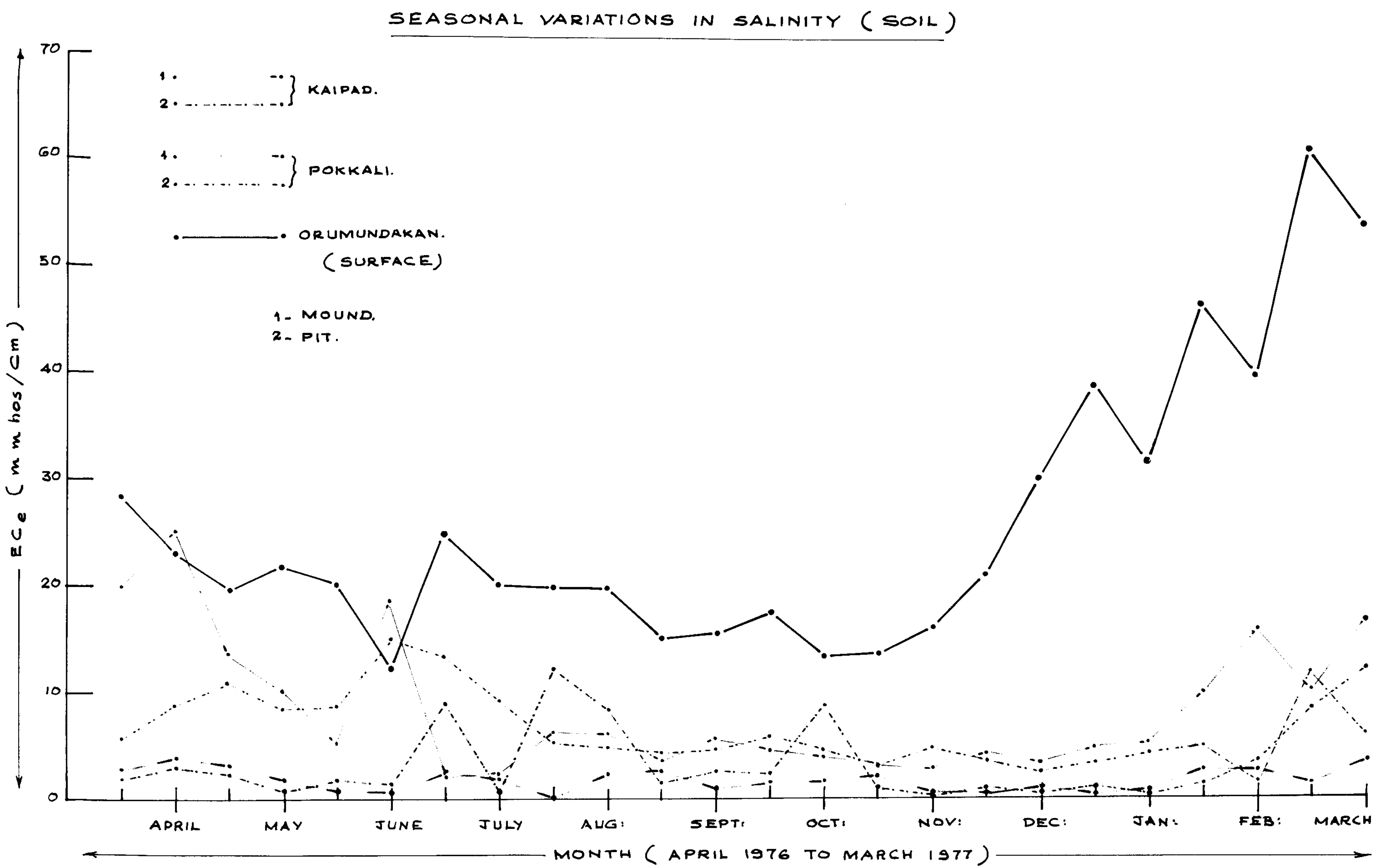

SEASONAL CHANGES IN SOIL REACTION
1 } KAIPAD.
2
1 } POKKALI.
2
ORUMUNDAKAN. (SURFACE)
1 - MOUND.
2. PIT.
pH OF THE SATURATION EXTRACT
8
7
6
5
4
3
2
APRIL
MAY
JUNE
JULY
AUG:
SEPT:
OCT:
NOV:
DEC:
JAN:
FEB:
MARCH
MONTH ( APRIL 1976 TO MARCH 1977 )

samples. It is significant to note that the saturation extracts of the various horizon of the Puthuvaippu profile contain a fairly high quantities of K. Taking into consideration the total potassium content in the soil and the amounts present in the saturation extract, it is seen that the quantity present in the saturation extracts range from 1/10 to 1/40th of the total K content in the soils. The soils being of lacustrine-alluvial origin, are therefore likely to contain potassium bearing primary minerals and clay minerals. Another significant result is that these soils are fairly well supplied with potassium except the sandy soils of the Orumundakan tract. Based on computations with the K data with saturation extract it is seen that except for the Karunagapally soils, all the others contain 100 to 2000 kg of K per hectare in the soil solution at field capacity. This indicates that these soils do not require any application of potassic fertilisers. The Karunagapally soils however require application of potash. The KAR values of the soils, in general, range between 0 and 3.3 and in many of them management of the acidity with cheaper non-magnesium containing liming materials will provide balanced nutrition with respect to monovalent and divalent cations.

SAR and ESP.

The ESP values, in general, range between 13.7 and 33.3 for the profile and surface samples collected from various locations. It has been reported by Bernstein and Pearson (1956)

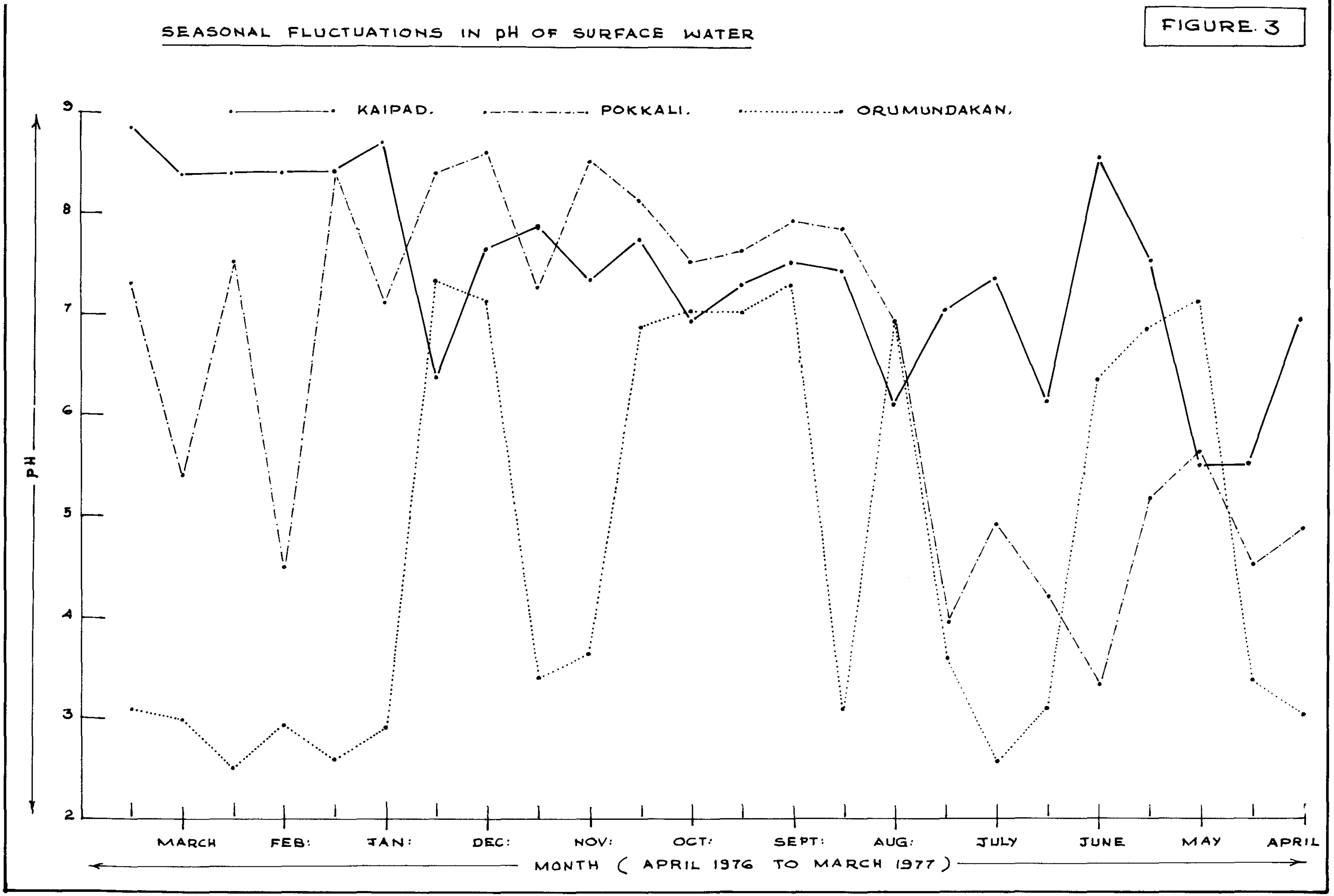
FIGURE. 2


SEASONAL VARIATIONS IN SALINITY (SOIL)
1. } KAIPAD.
2.
1. } POKKALI.
2.
ORUMUNDAKAN. (SURFACE)
1- MOUND.
2- PIT.
ECe (m m hos / cm)
70
60
50
40
30
20
10
0
APRIL
MAY
JUNE
JULY
AUG:
SEPT:
OCT:
NOV:
DEC:
JAN:
FEB:
MARCH
MONTH (APRIL 1976 TO MARCH 1977)

that when ESP exceeds 10 per cent for the fine textured soils and 20 per cent for coarse textured soils the structure deteriorates; no doubt these soils being puddled paddy soils have no structure, and so the question of deterioration of soil structure does not arise (Pearson and Bernstein, 1958). Due to conditions of flocculation and deflocculation depending upon the soluble salt contents of the water, there is a possibility of clay migration to lower layers, and a tendency for the formation of clay pan layers. However, the mechanical analysis data does not point to the development of clay pan layers. The SAR depicts the ability of the saturation extract to push sodium ions into the exchange complex. The SAR and ESP values are generally numerically equal over the ranges of concentrations encountered in the saline and saline alkali soils (U.S.S.L, 1954). The observed SAR and ESP values ranging to a maximum of 25.0 and 26.3 observed in February-March in some of the locations of the Pokkali, Kaipad and Orumundakan soils, however, get reduced to values ranging between 1 and 3 by July-August and November. The leaching by rain water and the consequent decrease in SAR and ESP is an annual feature and as such the possibility of exchangeable sodium creating any permanent physical changes in the soil, appears to be remote.

Periodical changes on salinity.

Unlike the arid saline soils of N. India, the coastal saline soils of Kerala being situated either at or below sea level undergo periodical inundation with salt water due to tidal effects and periodical flushing out of the saline water by flood waters in the rainy season. Leaching is also caused by the rain water falling into the fields. Thus the levels of salinity found at any period is due to the initial salinity status at the end of the summer prior to the onset of monsoon and leaching that is brought about by both flood waters and the rain water received in the field during the south west and north east monsoon periods. The leaching action, thus depends not only on the hydrological interactions and the initial levels of salinity, but also on the surface and internal drainage of the soils, which in turn are decided by the land form and soil properties. As far as the paddy crop is concerned it cannot stand high salinity upto 6 week's growth stage (Bernstein, 1974). It has been reported that paddy plants can tolerate higher levels of salinity at a growth stage beyond the seedling stage; but it is known to become once again sensitive to salinity during pollination and fertilisation stages (Pearson and Bernstein, 1959). For these reasons reflooding and drainage of paddy soils at this stage by fresh water may be beneficial, if facilities are available. The maximum permissible salinity level at seedling stage and at pollination and fertilisation stages is


SEASONAL FLUCTUATIONS IN pH OF SURFACE WATER
FIGURE 3
KAIPAD.
POKKALI.
ORUMUNDAKAN.
pH
9
8
7
6
5
4
3
2
MARCH
FEB:
JAN:
DEC:
NOV:
OCT:
SEPT:
AUG:
JULY
JUNE
MAY
APRIL
MONTH ( APRIL 1976 TO MARCH 1977 )

4 mmhos/cm for non-tolerant and semi-tolerant varieties and about 6 mmhos/cm for tolerant varieties (Tajuddin, 1977 Per. communication). In view of the cultivators' practice of sowing seeds in mounds in the Pokkali and Kaipad regions as already mentioned, it was decided to evaluate its beneficial and other effects in terms of leaching of soluble salts, and acidity. The periodical samples from Vytilla and Payyanur were collected both from the mounds as well as pits in between the mounds. The seasonal variation in pH of the saturation extract between the mounds and the pits is a reflection of the effect of differing moisture regimes in the active acidity of the acid sulphate soils of these fields. It has been observed that there is a general increase in the pH of the mound samples in the months of April to December. This is the period when the mounds raised in March-April are subjected to intensive leaching by rain water. During the corresponding period the pH of the pit samples also increases but beyond June a gradual decrease till August is observed. This decrease is possibly due to the leaching down of the active acidity from the mounds and their accumulation in the pits. Beyond August however, the mounds and pits are fairly of the same pH till the month of October (Figure-1.).

The $EC_e$ shows a variation both with period and location of the sample. In general, for all the three locations the $EC_e$ of the soils decline from April to December-January (Figure-2). This decline can be closely related to the monthwise rainfall received during the period of study. Thus the decrease in the conductivity of the saturation extract of the soils to below critical levels can be brought about by taking advantage of the rainfall received during the south west and north east monsoons. This is exactly what is being done at present by fitting the cropping period into this period of low salinity levels. The results of the present study are in agreement with the observations of Banerjee _et al._ (1976) for the West Bengal saline soils. According to Arjan Singh and Singh (1974) monsoon rains are effective in checking the salt build up in the surface soil. Bandyopadhya et al (1970) reported that seasonal changes in soluble salt content can vary upto 100 per cent or even more and inversely related to soil moisture levels. The findings of these workers are in close agreement with the results of the present study on seasonal variation in salinity. In some of the Pokkali and Kaipad areas where the levels of salinity are not very high during the cropping season from July to December, even with a traditional saline resistant variety of 120-135 days duration instead of the present practice of sowing on the mounds, transplanting may enable two crops to be raised instead of one. This can be made feasible by raising the nurseries in less saline or non-saline uplands and transplanting them in the mounds. From the results it can further be seen that the conductivity of the soils from the mounds are higher than that from the pits till June. This is

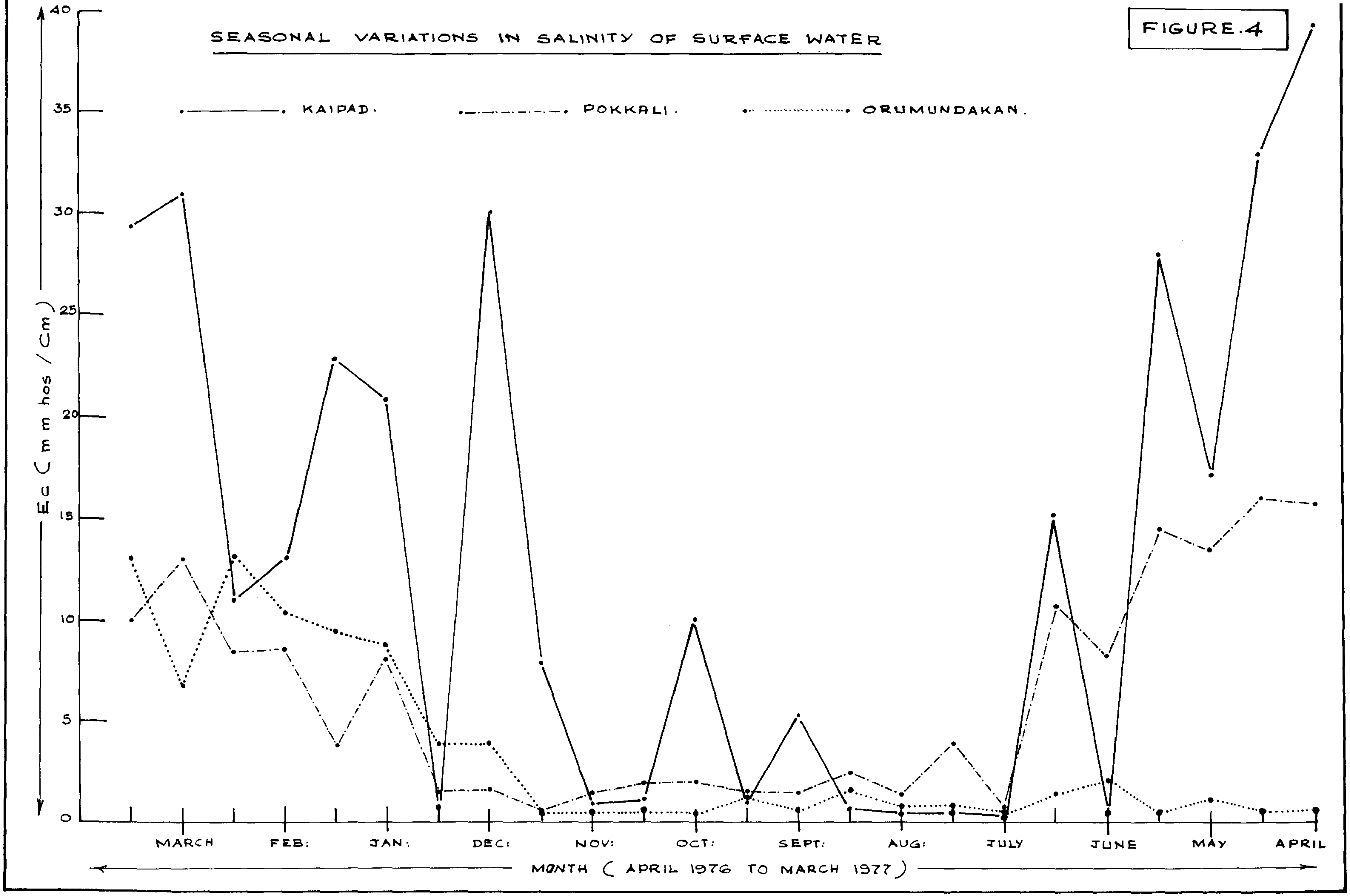


FIGURE.4
SEASONAL VARIATIONS IN SALINITY OF SURFACE WATER
KAIPAD.
POKKALI.
ORUMUNDAKAN.
Ec ( m m hos / Cm )
40
35
30
25
20
15
10
5
0
MARCH
FEB:
JAN:
DEC:
NOV:
OCT:
SEPT:
AUG:
JULY
JUNE
MAY
APRIL
MONTH ( APRIL 1976 TO MARCH 1977 )

probably due to alternate conditions of leaching and drying encountered by the raised mounds. The possibility of drying up of the mounds and capillary rise of soluble salts is however, minimised and more effective leaching brought about with the on set of heavy rainfall in June and July. The leached out salts accumulate in the pits and the higher $EC_e$ noted for the pit samples from August till January is partly due to this and partly due to the more prolonged submergence of the pit areas by tidal brackish waters. As discussed earlier, in case, transplanting is resorted to, it has to be confined to the mounds only since the pit samples record salinity above critical levels. The reduction in actual cropped area can to some extend mitigated by having a closer spacing and an increase in net income obtained by combining rice culture with pisciculture during the cropping period itself. The general pattern of decline in the levels of salinity observed during the period from June to December-January, corresponding to the monsoon seasons was deviated at certain sampling intervals. Thus for example in the Vytilla area the samples collected on the 30th June show a higher conductivity both in the mound and the pit samples than those recorded in the previous and, succeeding sampling dates. A similar observation has been made in August and September at Vytilla. A similar deviation was noticed in September in the Kaipad area also. It is possible that these deviations are caused by tidal effects during these periods, when the flood waters from the east to west were probably at a minimum. Along with the decrease in salinity the SAR values also decrease. Since this is happening every year, the higher ESP values observed for those soils in the summer months may be of little consequence in changing the physical properties of these soils.

The pH, EC, Cl and $SO_4$ content of the surface waters are closely related to the corresponding parameters of the saturation extract of the soil samples (Figure 3 and 4). In general the EC of the surface waters are far below those of the saturation extract of the soil which again goes to prove that salinization of the soil has been taken place over the years, by the periodic inundation with salt waters.

# SUMMARY

## SUMMARY

An investigation on the morphological, physical, physico-chemical and chemical properties including salinity aspects of the three types of coastal saline soils viz., Pokkali, Kaipad and Orumundakan was undertaken by studying six profiles and thirty four surface samples representing the three areas. In addition to this seasonal variation in the salinity levels on samples of soils from three marked locations viz., Payyanur (Kaipad), Vytilla (Pokkali) and Karunagapally (Orumundakan) were studied at fortnightly intervals from April 1976 to March 1977 in relation to the composition of the surface waters. The salient findings of this investigation and the conclusions drawn are summarised below.

1. All the profiles studied can be placed under the Order Entisols. The Vytilla, Puthuvaippu and Cherai profiles can be included in the sub order Aquents, the Karunagapally profile under Psamments, and the Vayalappra and Pallikkara profiles under the sub order Fluvents. These profiles can be listed under the great groups as follows; the former three in Haplaquents, the Karunagapally under Quartzi Psamments and the last two in the Ustifluvents. These soils can again be grouped under the following sub groups. The first three can be grouped under Aeric Haplaquents, the fourth under Aquodic Quartzi Psamments and the last two under Durorthidic Ustifluvents.

2. The texture of the soils vary from sand to silty clay. This wide variation in the textural group of the soils make the extent of salinity hazard different in different locations.

3. The absolute specific gravity ranges between 1.62 and 3.30 and the apparent specific gravity varies from 1.02 to 1.58.

4. The percentage pore space of the surface samples ranges between 17 and 63 per cent. The maximum value was recorded in a sample from Puthuvaippu.

5. The maximum water holding capacity was shown by a sample from Thuravoor, which incidentally also contained the highest amount of organic matter.

6. The organic carbon content varies between 0.12 and 3.69 per cent and a similar type of variation is observed in the total nitrogen content also. The maximum and minimum values recorded were 0.084 and 0.008 per cent.

7. All the soils except the soils of Puthuvaippu are extremely deficient in total phosphorus.

8. Contrary to the usual pattern observed in normal soils, magnesium is more abundant than calcium in these saline soils.

9. These soils are found to be rich in potassium and the K values for the surface samples vary from 0.10 to 0.63 per cent. The total sodium values for the surface samples range between 0.31 and 3.03 per cent.

10. Out of the 40 surface samples (this include 6 surface samples of the profiles) studied, 19 have a pH below 5.5, 11 have pH ranging between 5.5 and 6.5 and the remaining have a pH value above 6.5, but below 7.1.

11. It is observed that seven soils require lime application above 5 tons and an equal number require no lime application and the other samples need only intermediate levels of lime for their management.

12. A significant negative correlation between pH and sulphate (r = -0.532) and a similar correlation between pH and chloride (r = -0.461) has been observed.

13. A significant positive correlation between electrical conductivity of the saturation extract ($EC_e$) on the one hand, and chloride and sulphate content on the other has been observed.

14. The electrical conductivity of the saturation extract ($EC_e$), in general, varies from 7.6 to 226.3 mmhos/cm showing differences in the magnitude of salinity, encountered during the summer months.

15. In general, there is a consistent decrease in the electrical conductivity of the saturation extract ($EC_e$) with depth.

16. The ESP and SAR values in the equilibrium soil solution range from 13.7 to 33.3 and 11.7 to 34.8 respectively.

17. There is a significant positive correlation between clay content on the one hand and ESP and SAR on the other. A similar correlation exists between organic matter and ESP and SAR.

18. The sodium and magnesium content of the saturation extracts range from 78.3 to 591.5 and 19.2 to 573.0 me/l respectively.

19. Except the Karunagapally soils, all other soils contain approximately 100 to 2000 kg of potassium per hectare at field capacity ( computed from the values in the saturation extract) indicating thereby that only the sandy soils of Karunagapally area require potassic fertilisation.

20. The cationic and anionic composition of the soil solution indicate that these coastal saline soils are of the Na-Mg-Cl-$SO_4$ type.

21. In general, the salinity levels in the Kaipad, Pokkali and Orumundakan locations were decreased to below critical levels as the monsoon season progresses. The lowered levels are maintained till December-January.

22. The present system of mound cultivation facilitates more efficient leaching and thus establishing a salt free root zone for the crop sown in July-August.

23. The pits in between the mounds record comparatively higher salinity levels from July to November-December. This finding suggests that the present system of spreading the sprouted seeds into the pits may cause higher levels of salinity to the plants.

24. Though, in general, the salinity levels in the soils during the period August to January is below critical levels at certain sampling periods the conductivity levels have been observed to slightly increase from the general pattern. This has been attributed to the tidal influence.

25. The seasonal variation in the pH of the saturation extracts of the mounds and the pit samples represent fluctuations in the active acidity. These fluctuations have been attributed to the effect of differing moisture regimes in releasing active acidity from the acid sulphate-saline soils.

26. The conductivity of the surface waters is found to be below that of the saturation extracts of the soils. However, a close correlation exists between them.

27. It has been concluded that the leaching efficiency of the rain water depends not only on hydrological interactions and initial levels of salinity in the soil but also on the surface and internal drainage of the soils, which in turn, are decided by the land form and soil properties.

At present prawn culture is attempted in many areas during the off-season. Even during the cultivation season, mixed paddy culture with pisciculture appears to be a possibility and needs to be confirmed by trials. Engineering solutions to the problems of salinity may radically change the eco-system of the areas. Further cost benefit ratios of such projects is always high. In view of this, it is better to find out by research suitable soil and agronomic management systems for these areas. However, since wide variations in salinity are encountered in different areas, the salinity problem itself becomes highly location-specific. This calls for intensified multi-locational research efforts.

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*Original not seen

# APPENDICES

## Appendix-I. Rainfall data (mm) of Cannanore

| Year | Jan. | Feb. | Mar. | April | May | June | July | August | Sept. | Octo. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 1.0 | 0.0 | 0.0 | 288.3 | 219.9 | 301.7 | 907.7 | 430.7 | 309.7 | 159.2 | 230.1 | 1.3 | 2809.6 |
| 1961 | 0.0 | 8.1 | 26.9 | 176.6 | 356.8 | 649.3 | 1646.1 | 720.9 | 158.5 | 242.2 | 33.8 | 4.8 | 4024.0 |
| 1962 | 0.0 | 40.6 | 7.6 | 85.0 | 0.0 | 109.7 | 1240.5 | 582.1 | 235.9 | 286.0 | 0.0 | 0.0 | 2587.4 |
| 1963 | 5.1 | 53.3 | 72.5 | 60.6 | 150.0 | 274.7 | 761.2 | 667.2 | 631.3 | 164.7 | 3.9 | 0.0 | 2848.5 |
| 1964 | 0.0 | 0.0 | 46.5 | 78.2 | 72.8 | 296.8 | 758.8 | 1083.4 | 178.8 | 231.1 | 102.4 | 6.3 | 2855.1 |
| 1965 | 0.0 | 0.0 | 0.0 | 22.6 | 82.4 | 493.1 | 805.5 | 164.3 | 46.5 | 25.6 | 43.9 | 69.8 | 1753.7 |
| 1966 | 18.3 | 0.0 | 41.1 | 3.6 | 77.7 | 176.2 | 737.0 | 188.8 | 246.1 | 324.5 | 163.8 | 7.6 | 1984.7 |
| 1967 | 0.0 | 0.0 | 10.9 | 101.2 | 77.7 | 362.7 | 852.6 | 447.9 | 29.3 | 56.1 | 37.0 | 3.5 | 1978.9 |
| 1968 | 0.0 | 45.5 | 26.2 | 103.6 | 96.6 | 445.2 | 1285.4 | 530.3 | 292.2 | 53.6 | 35.0 | 0.0 | 2913.6 |
| 1969 | 0.0 | 0.0 | 0.0 | 85.3 | 140.8 | 327.4 | 995.7 | 388.2 | 190.0 | 141.7 | 84.5 | 713.8 | 3067.4 |
| 1970 | 7.9 | 0.0 | 0.0 | 160.2 | 141.8 | 299.2 | 621.5 | 551.5 | 20.4 | 47.6 | 117.3 | 0.0 | 1967.4 |
| 1971 | 0.0 | 0.0 | 0.0 | 3.7 | 81.2 | 530.2 | 533.4 | 319.1 | 0.0 | 150.6 | 12.0 | 31.0 | 1691.2 |
| 1972 | 0.0 | 0.0 | 0.0 | 141.5 | 233.7 | 390.1 | 747.7 | 250.2 | 104.4 | 167.7 | 11.7 | 0.0 | 2047.0 |
| 1973 | 0.0 | 0.0 | 0.0 | 47.9 | 206.8 | 595.2 | 755.6 | 537.0 | 180.0 | 79.7 | 0.0 | 29.1 | 2430.6 |
| 1974 | 0.0 | 0.0 | 37.3 | 77.5 | 88.0 | 1276.3 | 790.6 | 778.8 | 200.4 | 97.0 | 51.0 | 2.0 | 3398.9 |
| 1975 | 21.0 | 0.0 | 15.0 | 27.0 | 90.0 | 0.0 | 558.6 | 912.4 | 235.9 | 192.3 | 36.9 | 0.0 | 2089.3 |
| Mean | 3.33 | 9.21 | 17.75 | 98.92 | 132.6 | 407.98 | 874.86 | 534.55 | 191.46 | 153.1 | 59.7 | 54.32 | 2527.9 |
| 1976 | 0.0 | 0.0 | 4.2 | 210.3 | 31.5 | 83.1 | 745.3 | 459.6 | 177.3 | 157.2 | 148.3 | 0.0 | 2017.1 |

Source - Indian Meteorological Department, Trivandrum

## Appendix-II. Rainfall data (mm) of Ernakulam (Cochin)

| Year | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 13.2 | 3.4 | 245.2 | 195.2 | 829.4 | 584.9 | 558.2 | 350.9 | 530.2 | 216.9 | 235.2 | 32.6 | 3838.3 |
| 1961 | 0.2 | 15.9 | 1.2 | 159.5 | 670.9 | 816.3 | 783.2 | 646.3 | 526.3 | 209.0 | 85.4 | 1.9 | 3916.1 |
| 1962 | 7.3 | 98.3 | 54.5 | 70. 4 | 545.8 | 244.4 | 900.2 | 454.8 | 408.0 | 443.9 | 17.0 | 34.5 | 3329.1 |
| 1963 | 8.2 | 24.4 | 138.3 | 64.2 | 175.3 | 492.3 | 594.3 | 547.1 | 374.3 | 225.6 | 153.0 | 28.9 | 2826.2 |
| 1964 | 0.0 | 0.0 | 38.1 | 125.7 | 114.1 | 414.0 | 1007.1 | 409.8 | 472.0 | 452.9 | 100.9 | 3.0 | 3137.6 |
| 1965 | 33.6 | 11.2 | 69.5 | 201.2 | 519.5 | 702.4 | 515.9 | 309.5 | 199.5 | 119.0 | 139.1 | 276.0 | 3096.4 |
| 1966 | 5.8 | 2.4 | 8.4 | 92.7 | 45.7 | 612.7 | 966.4 | 208.8 | 587.8 | 406.2 | 475.9 | 177.7 | 3590.5 |
| 1967 | 122.0 | 0.0 | 50.2 | 64.3 | 850.4 | 944.0 | 1359.6 | 636.9 | 276.1 | 288.1 | 73.7 | 41.4 | 4736.7 |
| 1968 | 0.0 | 29.8 | 97.2 | 105.2 | 115.5 | 672.1 | 1453.5 | 256.4 | 335.0 | 183.1 | 95.0 | 28.0 | 3370.8 |
| 1969 | 12.8 | 17.8 | 2.2 | 154.9 | 319.9 | 733.7 | 893.3 | 182.3 | 240.4 | 325.6 | 124.2 | 181.3 | 3188.4 |
| 1970 | 169.2 | 0.0 | 66.6 | 176.6 | 375.8 | 723.6 | 623.4 | 446.2 | 340.8 | 254.6 | 88.4 | 0.0 | 3265.2 |
| 1971 | 44.5 | 16.1 | 24.0 | 56.6 | 575.7 | 822.8 | 732.5 | 424.5 | 350.1 | 116.8 | 39.9 | 29.7 | 3283.2 |
| 1972 | 36.7 | 17.5 | 0.0 | 69.7 | 741.4 | 441.8 | 668.0 | 212.0 | 225.7 | 466.9 | 235.9 | 268.9 | 3303.8 |
| 1973 | 0.0 | 7.0 | 0.0 | 118.0 | 129.8 | 648.0 | 582.0 | 547.8 | 92.0 | 298.3 | 135.0 | 32.5 | 2590.6 |
| 1974 | 8.2 | 1.4 | 4.2 | 151.0 | 457.7 | 251.9 | 344.3 | 415.4 | 293.9 | 133.7 | 188.5 | 0.0 | 2750.2 |
| 1975 | 1.4 | 20.2 | 19.4 | 101.0 | 136.8 | 839.9 | 472.3 | 556.1 | 436.7 | 513.3 | 185.1 | 21.0 | 3353.2 |
| Mean | 28.4 | 16.5 | 51.2 | 120.3 | 415.9 | 625.5 | 814.6 | 414.7 | 355.6 | 293.7 | 148.3 | 72.3 | 3353.5 |
| 1976 | 1.0 | 0.0 | 19.1 | 59.5 | 82.2 | 168.3 | 763.5 | 311.5 | 136.1 | 295.5 | 396.0 | 3.0 | 2247.3 |

Source - Indian Meteorological Department, Trivandrum

Appendix-III. Rainfall data (mm) of Quilon

| Year | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | 7.6 | 3.8 | 52.0 | 244.5 | 428.0 | 244.6 | 368.2 | 259.0 | 329.3 | 319.4 | 514.4 | 19.0 | 2849.8 |
| 1961 | 24.1 | 43.5 | 15.2 | 121.2 | 300.6 | 795.5 | 418.7 | 357.1 | 156.6 | 272.7 | 16.8 | 14.2 | 2536.2 |
| 1962 | 52.1 | 86.7 | 82.3 | 177.7 | 260.0 | 81.2 | 506.4 | 253.0 | 299.0 | 366.8 | 33.5 | 62.0 | 2360.7 |
| 1963 | 24.4 | 30.5 | 132.3 | 172.3 | 145.0 | 273.0 | 470.1 | 308.1 | 184.2 | 338.2 | 51.4 | 94.6 | 2224.0 |
| 1964 | 0.0 | 15.2 | 133.3 | 189.6 | 134.1 | 211.6 | 497.8 | 268.0 | 372.8 | 313.4 | 148.9 | 0.0 | 2284.7 |
| 1965 | 0.0 | 18.2 | 23.3 | 275.2 | 411.2 | 449.3 | 178.3 | 223.3 | 121.2 | 264.6 | 115.0 | 159.1 | 2238.1 |
| 1966 | 8.7 | 92.0 | 73.0 | 219.2 | 80.4 | 547.8 | 270.1 | 166.4 | 289.4 | 517.8 | 242.2 | 79.0 | 2586.0 |
| 1967 | 25.2 | 0.0 | 64.6 | 1[illegible].1 | 154.8 | 465.6 | 292.0 | 414.8 | 73.6 | 333.4 | 72.4 | 85.0 | 2090.3 |
| 1968 | 60.0 | 112.0 | 120.5 | 158.2 | 143.4 | 555.5 | 0.0 | 350.4 | 0.0 | 404.5 | 290.0 | 22.0 | 2216.5 |
| 1969 | 16.4 | 0.0 | 65.4 | 348.0 | 264.6 | 444.8 | 667.4 | 196.2 | 123.6 | 338.2 | 95.0 | 4.6 | 2564.2 |
| 1970 | 8.6 | 38.4 | 139.6 | 304.1 | 268.4 | 390.2 | 341.4 | 351.0 | 270.0 | 573.6 | 80.6 | 0.0 | 2765.9 |
| 1971 | 142.3 | 120.3 | 52.7 | 211.2 | 284.4 | 690.2 | 542.8 | 333.7 | 493.1 | 340.9 | 320.8 | 68.4 | 3600.8 |
| 1972 | 0.0 | 0.0 | 21.3 | 378.7 | 587.9 | 97.5 | 372.5 | 202.7 | 178.9 | 440.8 | 199.3 | 123.2 | 2602.2 |
| 1973 | 0.0 | 51.2 | 28.2 | 206.0 | 143.8 | 445.1 | 298.2 | 339.1 | 96.0 | 490.2 | 136.9 | 92.8 | 2327.5 |
| 1974 | 9.2 | 0.0 | 42.1 | 188.3 | 300.1 | 316.7 | 536.1 | 0.0 | 0.0 | 0.0 | 154.0 | 0.0 | 1546.5 |
| 1975 | 0.0 | 81.0 | 66.0 | 230.0 | 147.0 | 557.1 | 479.0 | 418.6 | 490.4 | 433.2 | 231.2 | 0.0 | 3129.5 |
| Mean | 23.7 | 42.9 | 75.8 | 220.7 | 253.4 | 410.4 | 389.9 | 276.3 | 217.4 | 359.2 | 174.0 | 51.5 | 2494.5 |
| 1976 | 0.0 | 0.0 | 63.3 | 321.6 | 191.2 | 179.7 | 349.0 | 145.0 | 97.0 | 192.0 | 320.0 | 78.0 | 1936.8 |

Source - IndianMeteorological Department, Trivandrum

# INVESTIGATIONS ON THE SALINITY PROBLEMS OF **POKKALI** AND **KAIPAD** AREAS OF KERALA STATE

BY

**V. SAMIKUTTY**

ABSTRACT OF A THESIS
submitted in partial fulfilment of
the requirement for the Degree:

MASTER OF SCIENCE IN AGRICULTURE

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KERALA AGRICULTURAL UNIVERSITY

DIVISION OF SOIL SCIENCE & AGRICULTURAL CHEMISTRY

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ABSTRACT OF THE THESIS ENTITLED "INVESTIGATIONS ON THE SALINITY PROBLEMS OF POKKALI AND KAIPAD AREAS OF KERALA STATE".


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The saline soils of the State viz., Pokkali, Kaipad and Orumundakan are coastal saline soils, which cover an area of about 30,000 hectares, cropped to a single crop of paddy. The profile characteristics of the soil reveal that they are Entisols. They contain varying levels of soluble salts depending upon their nearness to sea, backwater, or their situation on the flood plains of rivers and their nearness to the river mouths. The electrical conductivity of the saturation extract ($EC_e$) of these soils range between 7.6 to 226.3 mmhos/cm showing differences in the magnitude of salinity encountered, prior to the soils being leached in summer months. Though the soils are exhibiting extremely high levels of salinity in the summer months, they get decreased rapidly below critical levels for growing a successful saline resistant paddy crop by July-August. The observed SAR and ESP values ranging to the maximum values of 25.0 and 26.3 in the months of February-March rapidly get decreased to 1 to 3 by between August and November. These low levels of salinity are

maintained till December-January with an occasional spurt in salinity levels dependent on the opposing hydrological situation caused by the flood and rain waters on the one hand from east to west and the tidal waters from the west to the east on the other. The long period of nearly six months, when salinity in the soils are below critical levels, indicate the possibility of introducing a two crop system instead of one, provided nurseries are raised in non-saline uplands and transplanting resorted to in the raised mounds; previously leached free of soluble salts during the monsoon.

The cationic-anionic composition of the soils reveal that they are Na-Mg-Cl-$SO_4$ type of coastal saline soils. About 30 per cent of the soils studied have a pH below 5.5 and 15 to 20 per cent of the soils have lime requirement of more than 5 tons per hectare. In general the soils are extremely poor in phosphates and rich in potash. Application of non-magnesium containing lime materials at the time of mounding and subsequent leaching together with basal application of phosphate prior to planting are likely to enhance the yields of paddy in these areas. In short, the methods of management are highly location-specific calling for intensified research. The occurrence of saline water in the pits between the mounds even during the cropping period indicates the possibility of mixed rice culture with pisciculture.