INTERRELATIONS OF HUMANS WITH THE FERTILITY COMPONENTS OF WETLAND SOILS

By

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CERTIFICATE

Certified that this thesis entitled "Interrelations of humus with the fertility components of wetland soils" is a record of research work done independently by Ms.SREEDEVI.K under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship.

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INTRODUCTION

INTRODUCTION

SOIL ORGANIC MATTER, synonymously termed HUMUS, has over the centuries been considered by many as an `elixir' of life, especially plant life. Ever since the dawn of history, some eight thousand or more years ago, man has recognized the importance of organic matter and believed that the dark soils, commonly found in the river valleys and broad level plains are productive.

The amount of organic carbon stored in soils is nearly three times more than that in the above ground biomass. Globally, 1576Pg of carbon is stored in soils, with approximately 506 Pg (32%) of this being present in the soils of the tropics. (Eswaran et al. 1993). Adequate quantity of humus in the soil is a pre-requisite for maintaining soil health and sustained productivity. Sustainable agriculture, which is a matter of controversy among the planners and agricultural scientists, encompasses methods to use organic matter which enable the land to yield crops without the use of harmful agrochemicals or wasteful irrigation (Ellis, 1992). According to Arthur Wallace (1994), sustainable agriculture must be scientific, safe and sensible and one of the main conditions to be assured is the protection of humus in soil.

Humus arise from the chemical and biological degradation of plant and animal residues added to soil from time to time and by the synthetic activities of micro organisms. The products so formed, tend to associate into complex chemical structures that are more stable than the starting materials and gradually become an integral part of the soil matrix. The humus in soil, based on their solubility in acid and alkali, is separated into three distinct fractions designated as humic acid, fulvic acid and humin.

The important role played by humus in sustainable agriculture is through its own desirable properties as well as through the beneficial effects exerted on the physical, chemical and biological properties of soil. The physical properties modified by soil organic matter are the bulk density, aggregate stability, structure and water holding capacity. The effects of humus are remarkable on the chemical properties of soil, as it acts as a storehouse of nutrients, for plants as well as soil micro organisms. Humus is one among the chief attributes for high cation exchange capacity and buffering capacity exhibited by soils.

The content and composition of humus in flooded wetlands and nearby uplands differ very much. Ye and Wen (1992) studied the decomposition and properties of humus formed under flooded and non flooded conditions and reported significant differences in composition and properties. As reported by Bochlo *et al.* (1992), the specific air-water conditions in rice paddies cause severe changes in the composition of humus, leading to a specific type of humus called "Paddy soil humus".

The soil organic matter differs widely in quality and quantity in different soils of the State. Although several statistical estimations have been made to predict the relationship between soil organic matter and the fertility components of upland soils, a precise quantitative assessment of the actual content and contribution of SOM/humus and its fractions to various factors controlling the fertility of the wetland soils of Kerala has not been attempted so far. The wetland soils having a relatively higher content of organic matter than the upland soils, exhibit several characteristic features controlled by the prevalent microclimate and abundance of complex organic matter present in them. So far, there are no estimates on the humic acid and fulvic acid fractions of the SOM in wetland soils and their influence on the soil physical and chemical properties. The relationship between organic matter and nitrogen content of soil is invariably employed as a useful tool in soil testing for scheduling fertilizer programmes. It is highly essential that the precise relationship of organic carbon, and its fractions with total, available and organically bound nutrients other than nitrogen are also worked out for different types of wetland soils, in scheduling fertilizer programmes.

In the light of these considerations, the present study has been undertaken with the following main objectives:

1. To estimate the total content of soil organic matter and its fractions (non humified organic matter, humic acid and fulvic acid) in different wetland soils of Kerala.

2. To determine the content of total, available and organically bound nutrients.

3. To quantify the actual contribution of SOM to the total and available nutrients and important physical properties of soils and

4. To study the interrelationship of SOM and its components with the nutrient status and other soil properties in the wetland soil types.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Soil organic matter (SOM), the key component of the solid fraction of soil, includes plant and animal residues at various stages of decomposition, cells and tissues of microbes and the substances synthesized by soil micro organisms. The soil organic matter content differs widely in quality and quantity in different soils and the soils high in organic matter are generally considered to be fertile. The fertility of such soils is attributed to the slow release of nutrients from organic matter, made possible by the action of living microflora that utilise soil organic matter as a source of nutrients and energy. Thus, there is a close relationship between the availability of nutrients and organic matter status of soils. According to Allison (1973), under natural conditions, marked changes in organic matter content in the soil can occur only if there is a major difference in climate, which through its influence on rainfall and temperature, affects the vegetation as well as organic matter accumulation in soils. A brief review of the more important and latest literature on these aspects with special reference to the wetland soils of Kerala and India is presented here.

2.1. ORGANIC MATTER CONTENT IN SOILS

Schmidt and Schmidt (1963) and Harvey (1964) observed that the organic matter content did not register any marked variation between virgin and cultivated soils.

Gob et al. (1977) on the other hand, found that there was variation in the distribution and enrichment of the organic matter fractions both within a soil type and between soil types. Differences appeared to be primarily a function of the stage of decomposition and translocation of organic matter fractions through the soil profile rather than due to the differences in vegetation.

Sharma and Gupta (1987) based on a study on the composition and nature of humus in some forest soils of Himachal Pradesh reported that the content of humus in these soils varied from 0.145 to 1.59%.

Dhandayuthapani et al. (1989) have reported that pedogenic factors markedly influenced the organic carbon content of soils. It increased regularly with increase in both altitude and rainfall. At high altitudes, with increased amounts of rainfall, a luxuriant growth of vegetation occurs and such a stand of vegetation under low temperature favour the accumulation of organic matter.

Fang (1989) studied the characteristics and composition of humus in several types of paddy soils and found that the total humus content increased in these soils, while free and loosely combined humus decreased with the maturation of soils.

The average levels of organic matter in soils of Punjab and Himachal Pradesh were reported to be 28.6 and 46.7% respectively by Raina (1992).

Leinweber <u>et al</u>. (1993) based on the investigations of clay-associated organic substances, have reported that the organic carbon content in the dystric cambisol ranged from 0.5 to 10.2% and it was related to the genetic soil types, to management practices and to the duration of soil formation processes.

Bauhus and Khanna (1994) have reported that the soil organic matter content in a yellow podzolic and a red earth in South-East Australia varied widely and their values were 3.75 and 13.50% respectively.

Gregorich <u>et al</u>. (1995), while studying the soil organic matter turnover and storage of corn residue carbon found that after 25 years of continuous corn cultivation, 100 Mg C ha^{-1} was returned to the soil as residues, out of which 23 Mg ha^{-1} remained in the soil. It was also found that 30% of the soil organic carbon in the plough layer of soil was derived from corn.

Sahoo et al. (1995) estimated the organic carbon status in the Sundarbans mangrove soils which showed a wide variation in the four islands ranging from 0.29 to 1.89%, which was supposed to be due to the unequal leaf fall in the different areas.

Gaunt et al. (1995) conducted studies on the microbial biomass and organic matter turnover in wetland rice soils and found that the transition to continuously anaerobic conditions associated with the intensification of wetland rice systems affects their organic matter turnover and may adversely affect their productivity.

2.2. ORGANIC MATTER CONTENT IN SOILS OF KERALA

The status of organic matter in the soils of Kerala has been studied by several scientists. Kerala has 1,05,000 ha of natural wetlands and 75,000 ha of manmade wetlands. Pisharody (1965) has reported that, the rice soils of Kerala generally have an organic matter content varying from 0.03 to 2.86%.

Subramoney (1961) found high organic carbon in the peaty soils (Kari) of Kerala. Among the various wetland soil types in Kerala, the Kari soils record the highest content of organic matter which varied from 0.65 to 25%. According to the results published by Koshy and Britomuthunayagom (1961a), Zachariah and

Sankarasubramoney (1961), Nair and Aiyer (1968), Alexander and Durairaj (1968), Aiyer *et al*. (1975), Sreedevi *et al*. (1975), Kabeerathumma and Patnaik (1978), Aiyer and Nair (1979), Mathews and Jose (1984), Marykutty and Aiyer (1987) and several others, in *Kayal* and *Kārappadam* soils, the organic matter content varied from 0.4 to 5.5 and 0.49 to 13.9% respectively. The high level of organic matter in these soils has been attributed to the unfavourable conditions such as acidity and continuous flooding which has prevented a rapid degradation of organic matter (Korah and Koshy, 1987).

Praseedom and Koshy (1975) as well as Venugopal and Koshy (1976) studied the seven major soil groups of Kerala and found that the average organic carbon content in these sandy, alluvial, laterite, black forest, red and kari soils were 0.19, 4.16, 0.10 to 0.91, 0.40, 1.04, 0.39 and 9.03% respectively.

Krishnakumar (1978) found that in the black soils of Chittur taluk, the average organic matter content was 1.56% which decreased with depth in the profile.

Antony (1982) has reported that the average organic carbon content in the brown hydromorphic soils of Nedumangad, hydromorphic saline soils of Vyttila, coastal alluvial soils of Alleppey and riverine alluvium of Trivandrum were 1.6, 2.9, 0.25 and 0.63% respectively.

Organic carbon and clay content were closely correlated in different soil groups. Conditions which normally help the accumulation of clay fraction also favoured the accumulation of organic matter since both are colloidal in nature. (Usha, 1982).

Korah et al. (1991) have reported that the organic carbon content in the Vellayani redloam series varied from 0.33 to 0.67% and in the Neyyattinkara series, it varied from 0.42 to 0.72%.

Sheeba (1991) based on her studies on the major upland soils of South Kerala, reported that the organic carbon content in sandy, red loam, forest, lateritic midland and midupland soils ranged from 0.15 to 0.42, 0.15 to 0.67, 1.66, 0.45 to 0.96 and 0.9 to 1.38% respectively.

Ashraf (1992) found that the average organic carbon content in the soils of Trivandrum, Nedumangad and Palode series were 0.84, 0.36 and 0.41% respectively.

Sreekala (1993) has determined the organic carbon content in the soils of Pachalloor and Kottarakara and the values were reported to be 0.36 and 1.32% respectively.

Unnikrishnan (1993) has classified the wetland soils of Kerala and reported the organic matter content in them. According to him, Vellayani kayal soils had an average of 2.16%

organic matter, 2.06% in Karamana brown hydromorphic soils, 5.4% in Kari soils, 3.05% in Karappadam soils, 3.39% in Kayal, 4.1% in Pokkali, 2.32% in Kole, 1.93% in Pattambi and 1.21% in Kaipad soils.

Sanjeev (1994) has reported that the organic carbon in the surface samples of lakebottom soils of Vellayani lake ranged from 2.44 to 3.97%.

Recently, Abraham (1995) based on the studies conducted in the major rice soils of Kerala found that the average organic matter content in Kayal, Kari, and Onattukara soils were 4.05, 6.47 and 0.29% respectively. The Pattambi, Kole and Karappadam soils recorded an organic matter content of 1.88, 4.94 and 2.54% respectively.

2.3. FRACTIONS OF ORGANIC MATTER

The important fractions that make up humified organic matter in soils have been identified as humic acid, fulvic acid and humin. These fractions can be further sub-classified based on the differences in their solubility in acid, alkali, salt and alcohol.

Dobereiner (1822) used the term `Humic acid' for the first time to designate the alkali-soluble fraction of organic matter.

Oden (1919) described this component as a dark brown, almost black substance insoluble in alcohol, but soluble in alkali and precipitated by acids. He also described fulvic acid as a light yellow to golden yellow coloured substance soluble in alkali and acids. Kononova (1961) recorded a general inverse relationship between fulvic acid and humic acid content of organic matter. She found that the ratio of HA/FA varied between 0.3 and 2.5.

Krystanov (1967) has reported that an increase in pH, coupled with moderate moisture regime and microbial activity favoured the production of humic acid. Burges (1968) suggested that the synthesis of humic acid takes place during the decomposition of organic matter. According to Nguyenkha et al. (1969), the formation of humic acid was maximum in winter and minimum in summer. They also reported that the HA fractions were in a state of unstable equilibrium undergoing degradation as soon as they were formed.

Felbeck (1971) observed that HA was degraded to FA. Schnitzer and Khan (1972) also stated that FA was the resultant product of HA degradation.

Banerjee and Chakraborthy (1977) found that there was a regular variation in the nature, distribution and composition of humus in surface soils of India from different climatic regions.

They proposed that a moderate moisture regime and slightly acidic to neutral reaction were the main factors leading to the formation of humic acid while excess moisture and acidic conditions favoured the formation of fulvic acid.

Chatterjee and Ghosh (1981) found that hydrothermal conditions in soil influenced the complexity of structure and properties of humic substances. Humic compounds formed under constant wet conditions have less structural complexity and lower molecular weight than those derived from soils under alternate wet and dry conditions.

In a study on the fractionation of SOM in the upland soils of Kerala, Usha, (1982) has reported that the average value for the percentage of HA, FA and humin in SOM were 28.28, 36.51 and 35.21 respectively. HA and FA maintained a constant proportion irrespective of the variation in the content of total organic carbon.

Fang (1989) noticed that HA was the main component of SOM in black paddy soils whereas FA, the main component in yellow paddy soils. Calcareous paddy soils had the highest total humus and the lowest free and loosely combined humus.

According to Mishra and Srivastava (1990), the variations in the ratios of humic acid carbon : fulvic acid carbon (0.31 to 1.0), among different soils indicate the degree of humification under the influence of vegetation and agroclimatic conditions.

Moyano et al. (1991) estimated the carbon content of humic fractions in representative soils in Spain, to obtain information on the seasonal variation of organic carbon after one year of fallowing. High percentage of humic fraction in the total soil carbon, comprising of about 50%, implied a high stability of the SOM. Nearly all of the soil organic carbon was in humic form, of which about 42% was extractable with alkali.

Studies conducted on the nature and composition of organic matter by Raina (1992) in some soils of Punjab and Himachal Pradesh, indicated a predominance of FA in Punjab soils and of HA in Himachal Pradesh soils.

Human influence on soils has been reported to reduce their HA/FA ratio and humus levels. (Li, 1993)

Sen et al. (1994) conducted a comparative study on the effect of various types of organic manures on the humus characteristics of paddy soils. They have reported that the application of pig manure and rice straw increased the organic matter content of paddy soils. Application of pig manure increased the HA and FA contents while rice straw decreased the proportion of HA in the extracted humus.

Olk et al. (1995) from their studies on the characterisation of HA fractions from a Calcareous Vermiculitic soil, reported that the two HA fractions - the HA bound to monovalent cation and that bound to Ca or bivalent cation were chemically distinct. But these carbon pools represented early and late stages of humification processes in aerated soils in temperates.

Sahoo et al. (1995) conducted a study on the organic carbon status in the Sundarbans mangrove soils and found that the humus carbon fraction was very low ranging from 0.08 to 0.78% which was supposed to be due to either less humification or clay - humus complexation. The ratio of HA carbon: FA carbon was always less than one, indicating less humification.

2.4. ORGANIC MATTER AND SOIL PROPERTIES

SOM plays a pivotal role in the maintenance of soil fertility and productivity. This ubiquitous soil constituent has received considerable attention from many scientists of different disciplines. But even today, the knowledge of the nature of SOM and the manner in which it influences the soil fertility and other soil properties is far from complete. The effect of organic matter may be direct or indirect. Directly, organic matter acts as a source of plant nutrients and indirectly it influences the physical and physico-chemical properties. It is also known to produce certain physiological effects through the production of growth hormones and auxins.

SOM, producing favourable physiological effects on crop plants, holds a central position in organic farming. It is important in soil water relations, soil warming, availability of plant nutrients, ion exchange, chelation and buffering. A brief review of the work done on the relationship between SOM and various properties of soil is attempted.

2.4.1. ORGANIC MATTER AND SOIL PHYSICAL PROPERTIES

Soil structure is the major physical property which influences plant growth and it can be measured in terms of porosity, aggregation and bulk density. The impact of the structure of a soil may be expressed in terms of the content and pattern of transmission of water, air and heat. It is commonly recognized that these properties are directly linked to the organic matter levels in soils.

Viro (1962) reported that the water holding capacity of the soil principally depends on the contents of fine particles and organic matter. In forest soils, WHC depended mostly on organic matter content. Biswas and Khosla (1971) observed an increase in soil water retention characters by applying FYM to soils over a twenty year period, along with an increase in the organic matter status of the soil. Organic matter has an influence on the amount of retention and transmission of water in soils. Gupta _et al_. (1977) found that incorporation of digested sewage sludge increased soil water content at all suctions.

According to Larson and Clapp (1984), increasing amounts of organic matter in soils will usually be accompanied by increased aggregate porosity, lowered aggregate density and a narrow range in aggregate size distribution which will result in lowered soil bulk density. Dhandayuthapani (1985) reported that porespace, water holding capacity and volume expansion showed a significant positive relationship with organic carbon content in the soils of Tamil Nadu. These soils showed an enhanced WHC which was attributed to their high organic matter content. (Anandan, 1988)

Gbadegesin (1989), based on the studies on the influence of organic matter and texture on some moisture characteristics of soils of Nigeria, reported that organic matter is the most important parameter, contributing more than 35% and 42% respectively to the explanation on the variation in the available moisture content and WHC of soils.

Usha *et al*. (1989) found a negative correlation of bulk density and particle density with FA fractions in the red loam soils of Kerala.

Kahle *et al*. (1992) studied the influence of SOM on selected soil physical properties in six long term field experiments with and without organic fertilizers. They found that the soils fertilized with organic materials were characterized by lower bulk density and particle density. However, they had a greater porosity.

Snyder *et al*. (1993) found organic matter to be associated with increase in WHC and that the effect of organic matter was more pronounced in soils with oxidic and kaolinitic mineral suite.

Korshens (1993) reported a close linear dependence between organic matter and the physical properties in the soils of Central Germany.

Studies on natural soil by Hudson (1994) also revealed a highly significant positive correlation between organic matter and available water content which became more than doubled when SOM increased from 0.5 to 3% .

Thakur *et al*. (1995) found that in soils after rice harvest, significantly lower values of bulk density were recorded due to green manuring with daincha, which resulted in a build up of organic carbon in soil. During decomposion of green manures polysaccharides, cellulose and humus are produced which are responsible for the firm binding between soil particles resulting in more stable aggregates causing a reduction in bulk density. This decreased bulk density was closely related with increased cumulative infiltration.

2.4.2. ORGANIC MATTER AND SOIL-CHEMICAL PROPERTIES

Two of the important chemical properties of soils such as cation exchange capacity and soil buffering capacity, which contribute a major share to the fertility status, are influenced considerably by the SOM content.

2.4.2.1. Effect on buffering capacity of soil

The importance of organic matter in buffering the soil against undesirable effects from soil acidification in the tropics cannot be ignored. As early as in 1921, Stephenson has stated that highly organic soils and clays exhibited a high degree of buffering while coarse sands showed little of this capacity and that liming is essential when the amount of exchangeable hydrogen exceeds the amount of exchangeable calcium in soils. Forsyth (1947) indicated the presence of carboxylic, phenolic, methoxyl, acetyl, quinone and carbonyl groups in humic acids, which are actually relevant in the expression of buffering capacity of soils.

Studies conducted in various soils as published by Keeny and Corey (1963) and Helling et al. (1964) have shown that organic matter is an important determinant of lime requirement, buffering capacity and pH of acid soils.

Soundararajan (1965) obtained a close correlation between organic carbon and pH. Primavesi (1968) and Palaniappan (1975) have reported an increase of SOM with a decrease in pH. Kaliz and Stone (1980) identified organic matter as a buffering agent in soils and stated that it is an essential factor in the mineral nutrition of crops.

Magdoff and Bartlett (1985), based on their studies on Vermont soils, stressed the importance of organic matter in strongly influencing the degree of buffering and pH of soils. The soils were reported to be well buffered above pH 7 and below pH 4. The degree of pH buffering was reported by them to be inversely related to CEC and buffering. Bache (1988) showed that organic matter has a buffering capacity 300 times more than that of kaolinite.

Aitken et al. (1990) studied the pH and buffer capacity of forty acidic surface soils of Queensland and reported that the effect of CEC (slope of a curve showing change in CEC with pH) on buffering capacity was highly significant and the major soil property affecting CEC was the organic carbon content.

Hedin et al. (1990) based on a field experiment conducted to test whether organic acids buffer acid deposition in North Western U.S found that soluble constituents of organic carbon were not reduced by acidification and that the organic-acid-base systems had only very limited capacity to buffer inputs of strong mineral acids.

Aitken (1992) proposed that hydrolysis of aluminium absorbed by organic matter is a source of pH-buffering in soils.

Falkengren et al. (1993) found that free ionic Al in soil solution correlated well with both organic Al and pH. Tavant et al. (1994) also found a close relationship between organic carbon and pH in some French forest soils.

2.4.2.2. **Effect on Cation Exchange Capacity of soils**

Venugopal and Koshy (1976) studied CEC in relation to the mechanical composition and organic matter status of some soil profiles in Kerala and reported that the relationship between organic matter and CEC for all the soils was positive.

Martel *et al*. (1978) reported that the CEC of organic matter increased with depth in a soil profile from 56.5 to 223.0 me/100g. The contribution of organic matter to CEC of surface soils was low, and it ranged between 7 to 16%.

Kaliz and Stone (1980) identified organic matter as the chief source of exchange capacity in soils. They also found that CEC increased about 30 me/100g organic matter per unit increase in pH value.

Drake and Motto (1982) estimated the CEC, clay content, and organic matter content in a number of New Jersey soils. Based on regression analysis, it was indicated that 59 percent of the variation in CEC of all soils studied could be explained by variations in clay and organic matter contents, with the clay having a CEC of 35 and organic matter with 217 me/100g.

Based on the studies conducted in some forest soils of Himachal Pradesh, Sharma and Gupta (1987) reported that CEC showed a significant relationship with humic acid. While the relationship between fulvic acid and CEC was not significant.

Prasad *et al*. (1987) have shown that the functional groups of soil humus contributed to CEC and destruction of SOM would lower the CEC of whole soil.

Qixiao and Yu (1988) reported the positive influence of SOM on soil buffering capacity and CEC. Thompson <u>et al</u>. (1989) have reported that organic matter on an average contributed 49% of the CEC and 19% of the specific surface area of the fractionated soil materials in soils of Central Iowa.

Usha <u>et al</u>. (1989) have indicated a high positive correlation of humic acid with CEC in the red loam soils of Kerala. They also reported a positive correlation of fulvic acids and humin with CEC.

In a study conducted to summarise the relationship of CEC with clay and organic matter contents in the soils of the state of Indiana, Franzmeier <u>et al</u>. (1990) found that while on an average 100g of clay contributed to only 59 me CEC, 100g of organic matter contributed to 208 me CEC.

Piasick <u>et al</u>. (1990) reported that in the muck and muck containing soils of Mazury, the CEC was closely correlated with the organic matter content. Pallo (1991) also reported a similar relationship in gley soils of Burkina Faso.

Rajendran (1991) has shown that 64% of the CEC was contributed by organic matter in some of the selected Oxisols and Ultisols of Kerala.

Ross _et al_. (1991) found that in the Spodosols of a forested watershed in Vermont, with a pH below 5.3, the CEC was linearly correlated with organic matter.

Based on the investigations of clay associated organic substances, Leinweber _et al_. (1993) showed that the CEC of clay fractions was closely correlated to the organic carbon concentration. Surface area and CEC values were correlated linearly with the organic matter content in the bottom layers of unlimed acidic sandy forest soil.

Tavant _et al_. (1994) have obtained a close relationship between organic carbon and CEC in some French forest soils.

2.4.3. ORGANIC MATTER AND PLANT NUTRIENTS

The availability of plant nutrients like nitrogen, phosphorus, potassium, calcium and magnesium in soils is largely controlled by SOM content. The knowledge about the exact contribution of humus to the total and available nutrients in soils are far from complete. The influence of SOM on the availabily of plant nutrients has been widely reviewed and documented. Some of the studies in this direction are reviewed.

2.4.3.1. ORGANIC MATTER AND NITROGEN

Observations of Black (1968) indicated that the inorganic form of soil nitrogen constituted only less than 2 percent of the total nitrogen and the rest was in organic form and that nitrogen accounted for about 5 to 6 percent of SOM by weight.

Ramadass (1970) obtained a high correlation between available nitrogen and organic matter in the soils of South Arcot, Tamil Nadu. Orlov et al. (1971) suggested humin as the major contributor towards total nitrogen in soils. Bhat and Mohapatra (1971) have reported a positive correlation between organic carbon and available nitrogen, when the organic carbon content was greater than 0.7 percent.

Ohta and Kumada (1976) investigated humus forms of forest soils and found that nitrogen in humic, fulvic and humin fractions increased with the progress of decomposition and that the largest relative increase was found in fulvic acid nitrogen.

Thakur et al. (1976) suggested that percent of organic carbon can be used as an index of available nitrogen in soils. Singh and Singh (1982) found a significant positive correlation between organic matter and total and available nitrogen.

According to Stevenson (1982), the main identifiable organic nitrogen compounds in soil are aminoacids and aminosugars. Soils also contain trace quantities of nucleic acids and other nitrogenous biochemicals.

Mohapatra and Khan (1982) reported that in rice soils of India, amino acid nitrogen ranged from 51.8% in alluvial soils to 57% in acid sulphate soils. Mohapatra and Khan (1983) further stated that amino acid nitrogen made substantial contribution to the potentially mineralizable nitrogen in waterlogged rice soils.

Usha and Jose (1983) reported a positive and significant correlation between organic carbon and total nitrogen in the laterite soils of Kerala.

Chibba and Sekhon (1985) and Dhandayuthapani (1985) while studying the influence of carbon levels on the availability of nutrients found that total and available nitrogen presented a significant and positive relationship with organic carbon and all the fractions of organic matter.

Based on a study of nitrogen in humic substances, Stevenson and He (1985) reported that a significant amount (> 50%) of soil nitrogen occurs as structural component of humic substances, a portion of which is biologically stable and not readily available to plants.

According to Anandan (1988), humic acid is very closely related to total nitrogen while fulvic acid is more closely related to available nitrogen.

Ilango (1988) found that green manuring increased the different nitrogen fractions in flood water in some clayey soils of Tamil Nadu.

Dongale and Patil (1989) reported that organic carbon and total nitrogen content decreased in soil below 15 cm. While organic carbon was positively correlated to total nitrogen down to 45cm, the degree of correlation decreased below 15 cm.

Mueller et al. (1989) in his studies on the mineralization of nutrients after forest clearance noticed that the nitrate concentration in soils were twice as high in plots which are high in organic matter than in plots lower in organic matter.

Usha et al. (1989) reported a positive correlation between HA and FA with total nitrogen in the red loam soils of Kerala. Dhandayuthapani et al. (1989) also reported a similar correlation in soils in the hill region of Tamil Nadu.

Recke et al. (1990) from studies on the composition of EUF-organic nitrogen fractions in soils, reported that humus content was closely correlated with hydrolysable aminoacids.

Andreux and Theng (1990) reported that organic form is the major reservoir of nitrogen in many variable charge soils. The reactions of bimolecular and humic bound nitrogen with the surfaces of clay minerals and allophane are related to plant availability.

Kanthaliya and Bhatt (1991), based on a study on soils of Rajasthan have reported that, organic carbon is positively related with available nitrogen and organic carbon can be suitably used as an index of available nitrogen.

The transformation of nitrogen reserves in soil was shown by Yefimov and Osipov (1991) to depend not only on the humus content, but also on its composition. Moyano et al. (1991) reported that about 50% of the total nitrogen in semiarid soils of Spain was present in humin.

Ammonium fixation by humic substances was studied by Thorn and Mikita (1992). Data from ^{15}N NMR spectra showed that ammonia reacted similarly with all samples of HA and FA, indicating that functional groups which react with ammonia exist in common structural configurations in all samples. Most of the incorporated nitrogen was in the form of indole and pyrole nitrogen.

Palaniappan and Natarajan (1993) found that 95% of nitrogen, was associated with the organic matter components in soil.

Based on a study with the CPMAS spectra of HA and FA obtained from six German soils, Knicker et al. (1993) concluded that 10% of the total nitrogen in SOM can be present in hetero-aromatic structures or schiff bases.

According to Zak et al. (1993) only a fraction of labile SOM is annually metabolized within the Great lake forests and the local climate rather than the chemistry of labile SOM appeared to be an important factor constraining the annual in situ flux of nitrogen from this pool.

Thakur et al. (1995) reported an increase in the build up of available nitrogen due to green manuring which increased the organic carbon content in the soil.

Sahoo et al. (1995) found that the relationship between total and available nitrogen with organic carbon was positive, but the correlations were not significant, due to weak association of nitrogen with organic matter.

2.4.3.2. ORGANIC MATTER AND PHOSPHORUS

Kaila (1963) was of the view that SOM is an important source of phosphorus for plants containing atleast 25-50% of soil phosphorus in the organic fraction. Widely varying contribution has been proposed by several scientists. Mortensen and Himes (1964) reported that 15-80% of the total phosphorus in soil is contributed by SOM. According to the estimates of Swaby (1968), only 60% of phosphorus is associated with the organic compounds in soil.

Nagi (1978) and Mehta et al. (1979) correlated available phosphorus to different soil properties and found that it is positively correlated with organic matter and Organic phosphorus.

Bowman and Cole (1978) from studies on fractionation of organic phosphorus in grass land soils reported a high percentage of organic phosphorus in these soils, which was found to be resistant to mineralization.

Somani and Saxena (1979) found that the organic phosphorus content was highly correlated with organic matter. Ghosh et al. (1981) suggested that the forest soils recorded a higher status of organic phosphorus than the cultivated soils.

According to Ghose (1987) the amount of organic phosphorus in the major soil groups of Tamil Nadu were more closely associated with FA fraction of soils, thereby indicating that most of the organic phosphorus compounds were in the least polymerised fractions.

Dhandayuthapani *et al*. (1989) found that in the soils of hill regions of Tamil Nadu, the total phosphorus content is significantly and positively related to the organic carbon content. It was also found that the hymatomelanic acid, a fraction of SOM had a positive significant relationship with the total phosphorus in soils.

Usha *et al*. (1989) found that HA registered a negative correlation with Fe-P and Al-P and FA is positively correlated with total P.

Based on the studies conducted on seasonal storage and release of phosphorus and potassium by organic matter, Perrot *et al*. (1990) reported that labile organic phosphorus, microbial phosphorus and potassium and organic debris accumulated over winter and declined in spring. Amount of phosphorus released from labile organic and microbial phosphorus could contribute substantially to plant phosphorus requirements.

Jaggi (1991) based on his studies on phosphate fractions in some representative soils of Himachal Pradesh found that organic carbon bear significantly positive correlation with Al-P and Fe-P.

Kanthaliya and Bhatt (1991) reported that the relationship of organic carbon with available phosphorus was not significant in some soils of subhumid zone which was due to the fact that available phosphorus included mostly of inorganic phosphorus.

Sood et al. (1991) found that organic carbon alone accounted for 82.2, 78.0, and 63.5 percent variation in organic phosphorus, inositol phosphorus and nucleic acid phosphorus respectively. A close relationship between organic phosphorus and organic carbon indicated that organic phosphorus was a part of organic matter and it varied with the content of organic matter in soils.

Benbi and Brar (1994) based on a study on the effect of organic carbon on crop response to applied P in the alkaline soils of Punjab, found that wheat response to P fertilizer was a function of organic carbon and Olsen-P. It was also found that as organic carbon increased, the amount of fertilizer phosphorus required to achieve the yield target decreased. The organic carbon and Olsen - P accounted for 97% of yield variation in wheat.

Sahoo et al. (1995) based on a study on the organic carbon status in the Sundarbans mangrove soils, found that the relationship between organic carbon and available phosphorus was significant and positive. Thakur et al. (1995) noticed that in a rice-wheat cropping system, green manuring increased the available phosphorus status in soils. This was due to the fact that the organic anions arising from decomposition of organic matter form stable complexes with Fe^{3+} and Al^{3+} and prevent their reaction with phosphate ions, thereby preventing P-fixation.

2.4.3.3. **ORGANIC MATTER AND POTASSIUM, CALCIUM AND MAGNESIUM**

The metallic cations K^{+}, Ca^{2+} and Mg^{2+} are associated with organic matter in two forms, either as a constituent of organic residues or as complexes which are adsorbed on organic matter. A high level of humus is especially important in the maintenance of adequate supply of the elements in an available form. Both the organic and inorganic colloids hold the metal cations K^{+}, Ca^{2+} and Mg^{2+} in exchangeable form, but the content of organic matter in the soil is particularly important as it has an exchange capacity ten times more than that of inorganic colloids.

Carolus (1933) found that an increase in Mg content was observed due to high organic matter in soil and due to the high organic matter present in acid soils, less exchangeable Mg was lost by leaching. As contrary to this, Prince <u>et al</u>. (1947) observed Mg deficiency in soils rich in organic matter and light in texture, which was supposed to be due to the variation in intensity of rainfall and leaching.

According to Nishita *et al*. (1956), although there is some difference of opinion as to the tendency with which humus holds potassium, there is certainly no doubt, that by means of exchange complex, it does decrease the loss by leaching.

Salmon (1963) has stated that organic matter of the soil holds substantial quantities of Mg in non-exchangeable form. At the same time, Purushothaman (1964) indicated a low content of potash in soils containing high amount of organic matter.

According to Allison (1973), humus behaves more like montmorillonite than kaolinitic clays and for a given ratio of exchangeable K to Ca and Mg on the exchange complex, plants tend to take up the divalent ions more strongly from the humus. This has the consequence that crops growing in soil high in humus are more likely to respond to K fertilizers than of those growing in kaolinitic soils.

Juo and Grimme (1980) observed that vegetation and organic matter were mainly responsible for the relatively high level of soluble and exchangeable K in the surface layers of some African soils, but labile K pools could be depleted rapidly with rapid decline of organic matter.

Hetsch (1980) found a high correlation between organic matter and exchangeable Ca in Podsols.

Chibba and Sekhon (1985) based on their studies on the effect of pH and organic carbon on the availability of nutrients in acid soils of Himachal Pradesh, reported that organic carbon was significantly and positively correlated with available K. The same result was also obtained by Dhandayuthapani et al. (1989). He observed that available K showed positive correlation with all fractions of organic matter, whereas available Ca and Mg showed a negative correlation with total organic matter and also with its fractions.

Brar and Sekhon (1985) obtained a positive significant relationship between organic carbon and available potassium 'in five benchmark soils in North India.

Singh and Datta (1986) and Ravikumar et al. (1987) have opined that watersoluble and exchangeable potassium in soils were positively correlated with the organic carbon content.

Jayaraman (1988) reported that the proportion of organically complexed Mg fraction was 4.2% of the total Mg in the soils of Coimbatore. He also observed that the organically complexed Mg and acid soluble Mg fractions increased as the organic carbon content of soils increased.

Asp and Berggren(1990) studied Ca uptake by berch in the presence of Al and natural FA and found that FA complexed Al and it would not be available for plant uptake and therefore could not affect Ca uptake.

A positive correlation of organic carbon with available K was observed by Mishra and Srivastava (1991). In the acid soils of India, Subbarao and Sekhon (1991) found that watersoluble and exchangeable K contents increased with organic carbon. They also found greater K solubility in soils with higher organic carbon when compared to those with lower organic carbon.

Kanthaliya and Bhatt (1991) obtained a positive but non significant relation between organic carbon and available potassium. The increase in the availability of potassium with increase in organic carbon was supposed to be due to the release of K from organic complexes. A similar result was also obtained by Gupta et al. (1991) in forest soils under different silvicultural systems.

Plitcha and Kuczynska (1992) found that with increase in transformation of organic materials in a forest soil, the calcium content decreased and the magnesium content increased.

Prema (1992) has reported that in the acid soils of Kerala, the organic carbon content had significant and positive correlation with available potassium, exchangeable calcium and total magnesium, which was attributed to the consequence of the release of nutrients on organic matter decomposition.

Tavant _et al_. (1994) based on a study on the relationship between organic carbon and exchangeable calcium found that, organic carbon explained for 77% of the variation in exchangeable calcium. The strong dependence of organic carbon on calcium resulted from organometallic complexation and the protective effect of calcium against microbial degradation.

Olk _et al_. (1995) extracted the mobile HA (MHA) and Ca HA from a calcareous soil and found that CaHA pool was protected from chemical and biological degradation through development of bonds to exchangeable calcium.

Sahoo _et al_. (1995) obtained a significant positive correlation between organic carbon and available potassium in the mangrove soils of Sundarbans.

MATERIALS AND METHODS

MATERIALS AND METHODS

To estimate the total content of soil organic matter (humus) in soils and to quantify its actual contribution and interrelationship with the nutrient status and basic soil characters of the major wetland soils of Kerala, fifteen samples of surface soil, each from Kari, Karappadam, Kayal and typical lateritic alluvial soils from Pattambi were collected. Samples of soil from the New Permanent Manurial Experimental (NPME) plots, receiving treatments of organic matter, in the R.A.R.S, Pattambi were also included.

LOCATION OF SITE FOR SOIL COLLECTION

a) KARI SOIL (Fine loamy, mixed, isohyperthermic, typic sulfaquent).

Sample No.	Location
K_1	Tharayakkari North
K_2	Tharayakkari South
K_3	Thakazhi
K_4	Munnoorampadavu-North
K_5	Munnoorampadavu-South
K_6	Kallepparam

K_7	Kavilthekkumpuram (1)
K_8	Kavilthekkumpuram (2)
K_9	Valiyathuruthu
K_{10}	Cheriyathuruthu
K_{11}	Ezhavankari
K_{12}	Karuvatta
K_{13}	Varikkattukari-North
K_{14}	Kochuputhenkari
K_{15}	Varikkattukari-South

b) KARAPPADAM SOILS. (Fine, mixed, isohyperthermic aeric tropaquept)

Sample No.	Location
M_1	Mancompu
M_2	Veliyanadu
M_3	Ramankari
M_4	Edathua
M_5	Veeyapuram
M_6	Niranam
M_7	Muttar
M_8	Kavalam
M_9	Kidangara
M_{10}	Chambakkulum

M_{11}	Kalathil Naalpathu
M_{12}	Kollanadi
M_{13}	Cheruthanni
M_{14}	Punnakkunnuthussery
M_{15}	Maniyankaripadam.

c) <u>KAYAL</u> SOILS. (Fine, mixed, Isohyperthermic, typic, hydraquent).

Sample No.	Location
L_1	Rajaramapuram Kayal
L_2	D-block (1)
L_3	D-block (2)
L_4	Mathikayal South
L_5	C-block
L_6	Mathikayal-North
L_7	Mangalam Kayal-North
L_8	Mangalam Kayal-South
L_9	Sreemoolam Kayal
L_{10}	Madathikayal-South
L_{11}	Venattukaripadam
L_{12}	Madathikayal-North
L_{13}	Moovayiramkayal
L_{14}	Venattukadkayal
L_{15}	Aaravankayal

d) LATERITIC ALLUVIAL SOILS. (Fine, kaolinitic, isohyperthermic, aeric kandiaqult)

P_1 to P_9	Pattambi
P_{10} to P_{15}	NPME plots of RARS, Pattambi treated with organic matter as
P_{10}	Cattle Manure @ 18 t ha^{-1}
P_{11}	Green manure @ 18t ha^{-1}.
P_{12}	Cattle manure @ 9t ha^{-1} + green manure @ 9tha^{-1}.
P_{13}	Cattle manure @ 9t ha^{-1} + NPK 45:45:45 kg ha^{-1}
P_{14}	Green manure @ 9t ha^{-1} + NPK 45:45:45 kg ha^{-1}
P_{15}	Cattle manure @4.5t ha^{-1}+green manure @ 4.5tha^{-1} + NPK 45:45:45 kg ha^{-1}

3.1. COLLECTION OF SOIL SAMPLES

Typical soil samples from the selected regions as shown above were collected by traversing across each area and taking the surface layer (0-15cm) with a spade from each of the locations at intervals of 15-20m. The samples thus collected were mixed well and composite samples representing each site were collected in polythene bags. The collection of soil samples was done during September-October, 1994 when the paddy fields were in the partially drained condition after the harvest of first crop of rice.

3.2. PREPARATION OF SAMPLES FOR ANALYSIS

The samples were dried in shade, powdered with a wooden mallet and sieved through a 2mm sieve. The sieved samples were stored in air-tight plastic containers. The samples were analysed for the following physical and chemical characters using procedures given below.

3.3. SOIL ANALYSIS

3.3.1. PHYSICO-CHEMICAL CHARACTERS OF SOILS

1. Soil reaction (pH)

The pH of the samples was measured in 1:2.5 soil-water suspension using a Perkin-Elmer pH meter (Jackson, 1973).

2. Waterholding Capacity (WHC)

Waterholding capacity of soil samples was determined using Keen-Raczkowski boxes (Keen - Raczkowski, 1921).

3. Cation Exchange Capacity (CEC)

10g of soil was treated with 50ml neutral normal ammonium acetate and kept overnight. It was filtered and the residue was washed with eight lots of five ml portions of neutral normal ammonium acetate and the excess ammonium was removed by washing with ethyl alcohol. The absorbed ammonium was estimated by distillation. (Jackson, 1973).

4. Soil Organic matter (SOM)

The organic carbon was determined by Walkley and Black's rapid titration method using ferroin indicator. The organic matter content in soils was calculated from organic carbon by multiplying it with the factor 1.724.

5. Buffering capacity (Lime requirement)

Buffering capacity of different soils was compared using buffer curves. Buffer curves were prepared by plotting the respective pH values of soil against the quantities of calcium oxide added. For this, 10g of soil was weighed out in a 50 ml beaker and the pH values of soil-water (1:2.5) suspension with the consecutive addition of unit quantities (10mg) of calcium oxide was noted.

6. Total Nitrogen

Total nitrogen was estimated by the Microkjeldahl method. (Jackson, 1973).

7. **Total Phosphorus**

1gm of soil was digested with 20ml concentrated nitric acid. 1ml of 60% perchloric acid was then added and the digestion continued until dense white fumes appeared.

Total P_2O_5 was estimated colorimetrically in the diacid extract of soil by Vanado-Molybdic yellow colour method in a Klett-Summerson photoelectric colorimeter. (Jackson, 1973).

8. **Total Potassium and Calcium**

Total potassium and calcium in the diacid extract of soil was determined using a Flame Photometer. (Jackson, 1973).

9. **Total Magnesium**

Total magnesium was determined in the diacid extract of soil using an Atomic Absorption Spectro Photometer (Perkin-Elmer-3030)

10. **Available Nitrogen**

Available nitrogen in soil was determined by alkaline permanganate method. (Subbiah & Asija, 1956).

11. **Available Phosphorus**

Available phosphorus in soil was extracted using Bray No.1 reagent and was determined colorimetrically by ascorbic acid blue colour method in a Klett-Summerson Photoelectric colorimeter. (Watanabe & Olsen, 1965)

12. **Exchangeable Potassium and Calcium**

Exchangeable potassium and calcium in the soil were determined in the ammonium acetate leachate collected during the determination of CEC, using an EEL Flame Photometer. (Toth and Prince, 1949).

13. **Exchangeable Magnesium**

Exchangeable magnesium in soil was determined from the ammonium acetate leachate collected during the determination of CEC using an Atomic Absorption Spectro Photometer. (Jackson, 1973).

3.3.2. DESTRUCTION OF ORGANIC MATTER IN SOIL SAMPLES

The organic matter in soil was completely destroyed by repeated digestion with 30% hydrogen peroxide and subsequent leaching with distilled water to make the residual soil free from soluble materials. The soil solution obtained after oxidation with hydrogen peroxide was filtered through a Whatman No.42 filter paper and made upto a definite volume. The residual soil left in the filter paper was air dried, weighed and stored in plastic containers for further analysis.

3.3.3. SOIL PROPERTIES LINKED WITH MINERAL MATTER

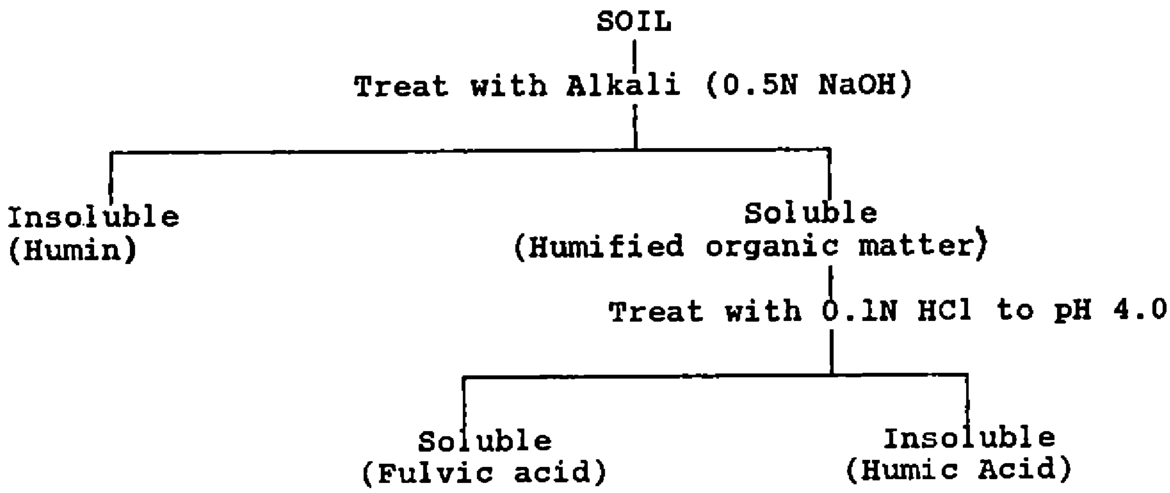
pH, water holding capacity, cation exchange capacity and buffering capacity of the residual soil after organic matter destruction was estimated by procedures described above.

3.3.4. SOIL PROPERTIES LINKED WITH ORGANIC MATTER

Content of nitrogen, phosphorus, potassium, calcium and magnesium in the hydrogen peroxide digested extract of the soil samples were estimated in suitable aliquots following procedures described as above.

3.3.5. EXTRACTION AND FRACTIONATION OF SOIL ORGANIC MATTER

Extraction and fractionation of soil organic matter was done on all the soil samples by adopting the scheme suggested by Stevenson (1965) as given below. Non humified organic matter content in soils was obtained by subtracting the humus content from the organic matter content determined by Walkley and Black's rapid titration method.



Humus, humic acid and fulvic acid in the organic matter of the soil samples were estimated and expressed as percentages of soil as well as SOM. HA/FA ratio was also calculated.

3.4. STATISTICAL ANALYSIS

The data generated from the different analysis described above were subjected to suitable statistical analysis to estimate the degree of variability of the soil properties within each soil type and between the four types of soils. Interrelationship between SOM, Humus, Humic acid, fulvic acid, Non humified organic matter and HA/FA with various soil properties were also estimated to determine the degree of association of each soil property on SOM and its various components. Further, these properties were subjected to regression analysis to derive the relationship between soil properties and SOM. The methods suggested by Panse and Sukhatme (1967) were used for the statistical analysis of the data.

RESULTS

RESULTS

The results of the study on "Interrelations of humus with the fertility components of wetland soils" are presented in this chapter.

4.1. GENERAL CHARACTERS OF SOILS

The general physical and chemical characters of the four wetland soil types used for the study are presented in tables 1-4 and the mean values of the various characters in each soil type are presented in table 5.

4.1.1. pH

Among the four soil types, as seen from tables 1 to 5 the lateritic alluvial soils of Pattambi are the least acidic. They recorded a range of pH values from 5.4 to 6.1 with an average of 5.6. The Kari, Karappadam and Kayal soils on the other hand are all acidic with pH values ranging between 3.2 and 4.9, giving mean values of 4.2 for Kari and Kayal soils and 4.4 for Karappadam soil. In all these soil types,pH values showed the lowest degree of variability within each soil type. Pattambi soils with significantly higher pH values, recorded a variability of only 2.8% followed by Karappadam, Kari and Kayal soils with a

TABLE - 1 GENERAL CHARACTERISTICS OF KARI SOILS

Sample	pH	WHC (%)	CEC ($Cmol\ Kg^{-1}$)	Total OM(%)	Lime Req. tha^{-1}	Total N_2 (%)	Total P_2O_5 (%)	Total K_2O (%)	Total Ca. (%)	Total Mg. (%)	Avail. N_2 $Kg\ ha^{-1}$	Avail. P_2O_5 $Kg\ ha^{-1}$	Avail. K_2O $Kg\ ha^{-1}$	Exch. CaO($Cmol\ Kg^{-1}$)	Exch. MgO($Cmol\ Kg^{-1}$)
K1	4.3	63.5	18.2	7.02	32	0.20	0.057	0.16	0.18	0.11	537.6	2.22	53.8	3.27	1.44
K2	4.3	66.4	17.9	7.62	32	0.50	0.040	0.13	0.22	0.11	418.2	0.02	354.8	3.33	1.42
K3	4.5	58.0	19.6	7.22	32	0.32	0.032	0.15	0.30	0.12	470.4	0.03	344.1	3.07	1.37
K4	4.7	63.6	20.1	3.97	28	0.24	0.038	0.18	0.42	0.15	483.6	4.45	365.6	5.67	1.41
K5	4.5	68.6	15.9	4.88	32	0.29	0.040	0.08	0.40	0.13	496.6	8.96	198.9	1.46	1.41
K6	4.4	74.4	18.4	3.56	28	0.20	0.015	0.18	0.38	0.12	408.4	4.48	134.4	3.02	1.40
K7	4.0	71.6	14.4	11.59	32	0.38	0.050	0.22	0.44	0.14	584.8	2.24	177.4	5.05	1.44
K8	4.0	76.3	26.5	12.31	28	0.38	0.069	0.14	0.48	0.15	568.5	2.24	322.6	4.63	1.39
K9	4.0	72.5	23.9	11.00	40	0.24	0.050	0.20	0.50	0.17	571.7	0.01	241.9	4.32	1.38
K10	4.2	51.2	8.5	1.83	16	0.12	0.050	0.05	0.48	0.10	342.9	4.47	145.2	2.39	1.03
K11	4.0	79.5	23.7	9.16	28	0.18	0.015	0.23	0.16	0.18	382.1	2.24	252.7	3.75	1.39
K12	3.2	66.5	34.1	12.22	28	0.30	0.050	0.60	0.14	0.18	455.2	2.24	80.7	3.38	1.58
K13	4.3	80.2	4.7	6.41	32	0.18	0.050	0.42	0.26	0.14	429.9	4.48	241.9	4.27	1.65
K14	3.9	85.4	23.6	10.14	32	0.32	0.067	0.55	0.44	0.16	403.0	2.24	430.1	4.16	1.52
K15	4.0	62.0	15.7	4.68	32	0.29	0.040	0.08	0.38	0.14	495.0	8.96	198.9	1.56	1.40
Mean	4.2	69.3	19.0	7.58	30.1	0.28	0.044	0.22	0.35	0.14	469.9	3.29	236.2	3.56	1.42
C.V (%)	6.5	13.1	37.5	44.7	16.5	35.4	35.3	74.3	36.1	18.1	15.7	85.0	46.7	33.4	9.4

variation of 6.1, 8.5 and 8.1%. These variations may be considered as not significant as the C.V. values are all below 10%.

4.1.2. Water holding capacity (WHC)

The four soil types showed significant difference in the average value for water holding capacity. WHC is highest for Kayal (80.8%) and lowest for lateritic alluvial soils (44.4%). Kari and Karappadam soils recorded an average WHC of 69.3 and 71.8% respectively as seen from Table 5.

All the soil types, except the Kayal soils are highly variable in their WHC, while Kayal soil recorded the least variation of only 7.2% between samples. The coefficient of variation in Kari and Karappadam soils is 13.1% and in lateritic alluvial soils it is 14.9%.

4.1.3. Cation Exchange capacity (CEC)

From the results, it is seen that Kari as well as Karappadam soils showed high degree of variability within soils with respect to their CEC. Kayal soils are the least variable (C.V.= 9.3%) and the lateritic alluvial soils showed the maximum variation of 20.8% between samples. Kari soils recorded the highest value for CEC ranging from 4.7 to 34.1 Cmol Kg^{-1} with an

TABLE 2 GENERAL CHARACTERISTICS OF <u>KARAPPADAM</u> SOILS

Sample	p^H	WHC (%)	CEC (Cmol Kg^{-1})	Total OM(%)	Lime Req. tha^{-1}	Total N_2 (%)	Total P_2O_5 (%)	Total K_2O (%)	Total Ca. (%)	Total Mg. (%)	Avail. N_2 Kg ha^{-1}	Avail. P_2O_5 Kg ha^{-1}	Avail. K_2O Kg ha^{-1}	Exch. CaO(Cmol Kg^{-1})	Exch. MgO(Cmol Kg^{-1})
M1	4.3	71.6	10.0	4.40	24	0.46	0.053	0.22	0.18	0.16	398.7	8.96	59.1	2.86	1.40
M2	4.4	69.2	21.4	10.51	24	0.56	0.055	0.41	0.16	0.17	591.4	8.96	118.3	3.38	1.56
M3	4.5	76.3	6.9	3.35	20	0.37	0.068	0.22	0.08	0.11	477.1	31.36	139.8	2.96	0.62
M4	4.9	55.3	7.1	3.35	28	0.21	0.130	0.24	0.16	0.10	342.7	2.24	161.3	3.69	0.76
M5	4.6	72.5	11.1	4.66	28	0.24	0.125	0.24	0.14	0.18	473.7	2.24	112.9	3.59	0.91
M6	4.2	92.1	11.9	2.91	32	0.36	0.098	0.19	0.14	0.19	418.9	0.02	112.9	5.10	1.03
M7	4.4	70.5	11.9	4.65	24	0.31	0.040	0.24	0.20	0.17	349.4	1.10	145.2	5.10	1.09
M8	4.6	54.1	20.0	7.46	28	0.31	0.060	0.36	0.22	0.19	380.8	8.96	112.9	2.91	1.19
M9	4.7	67.4	20.7	7.86	20	0.37	0.100	0.29	0.16	0.17	365.1	2.24	193.5	4.89	1.14
M10	4.3	73.0	10.8	5.06	32	0.30	0.100	0.19	0.26	0.19	351.7	2.24	118.3	4.78	0.97
M11	4.2	72.9	17.8	9.76	20	0.41	0.098	0.36	0.24	0.26	576.6	2.24	268.8	2.81	1.06
M12	4.2	72.5	23.3	9.21	32	0.24	0.073	0.29	0.16	0.15	500.6	2.24	198.9	3.69	0.98
M13	4.0	68.6	18.3	10.16	28	0.29	0.048	0.34	0.42	0.19	365.1	0.56	311.8	4.10	1.36
M14	4.5	76.8	19.6	7.05	28	0.18	0.038	0.17	0.40	0.13	345.0	2.24	59.1	3.59	1.11
M15	3.9	84.0	19.5	11.79	32	0.26	0.068	0.59	0.44	0.10	387.5	1.12	360.2	3.90	1.43
Mean	4.4	71.8	15.4	6.81	26.7	0.32	0.077	0.29	0.22	0.16	421.6	5.12	164.9	3.82	1.11
C.V (%)	6.1	13.1	36.1	43.5	16.7	28.4	38.6	37.8	49.4	25.5	19.7	154.1	53.4	21.3	23.0

average of 19.0 Cmol Kg^{-1}, closely followed by Kayal soils with a mean CEC of 18.1 Cmol Kg^{-1}. The Karappadam soils recorded an average CEC of 15.4 Cmol Kg^{-1} soil which is not significantly different from the Kari and Kayal soils. The lateritic alluvial soils recorded a significantly lower CEC value which ranged from 4.3 to 9.7 Cmol Kg^{-1} soil with an average of 7.0 Cmol kg^{-1} soil.

4.1.4. Organic matter

Kari, Karappadam and Kayal soils are found to be rich in organic matter and their contents ranged from 1.83 to 12.31, 2.91 to 11.79 and 5.69 to 11.28% respectively. At the same time, lateritic alluvial soil are much low in their organic matter status which ranged only between 1.45 and 3.41% with an average of 2.24% which is significantly lower than that in the other three soil types. This property also showed wide variation within each soil type which is higher for Kari and Karappadam (C.V.= 44.7% and 43.5%) soils and relatively lower for Kayal and lateritic alluvial soils (C.V. = 21.2% and 26.8%).

4.1.5. Lime Requirement (LR)

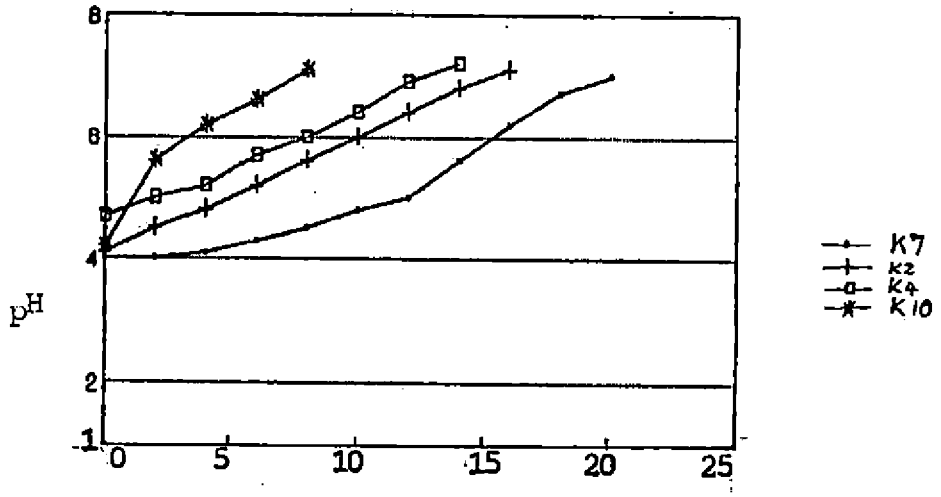
Lime requirement,ie the quantity of lime that is required to raise the soil pH to 7.0, showed considerable variation within Kari, Karappadam and lateritic alluvial soils (C.V = 16.5%, 16.7%

and 14.3% respectively). On the other hand, Kayal soils are found to be more or less uniform in their lime requirement (C.V. = 6.4%) The Kari and Kayal soils showed the highest values for lime requirement whereas the lateritic alluvial soils recorded the lowest value which ranged from 12 to 24 t ha^{-1} with a mean of 19.7t ha^{-1}. The average value of lime requirement for Kari, Karappadam and Kayal soils are 30.1, 26.7 and 30.7 tha^{-1} respectively. The lime requirement values of lateritic alluvial soils are significantly lower than that for Kari, Karappadam and Kayal soils.

4.1.6. Buffering Capacity

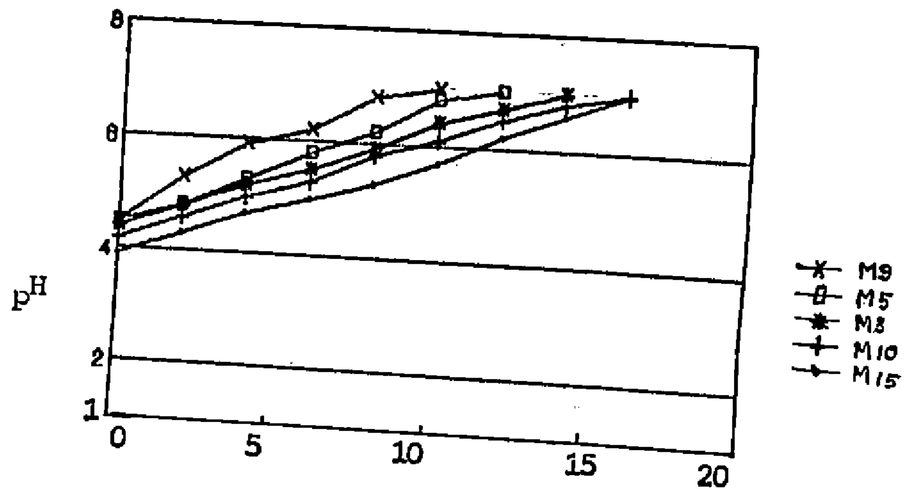
Buffering capacity expresses the resistance offered by a soil to change in pH due to the addition of any acidic or basic amendments or fertilizers. Buffering capacity of the four soil types are represented in the form of buffer curves in figures la-le. From the figures it is seen that the buffering capacity followed the same trend as that of lime requirement. Kari and Kayal soils are highly buffered where as lateritic alluvial soils are least buffered. Buffering capacity within each soil type also showed considerable variability, as seen from figures 1a-1d.

Fig.1a. Buffer curves for Kari soils



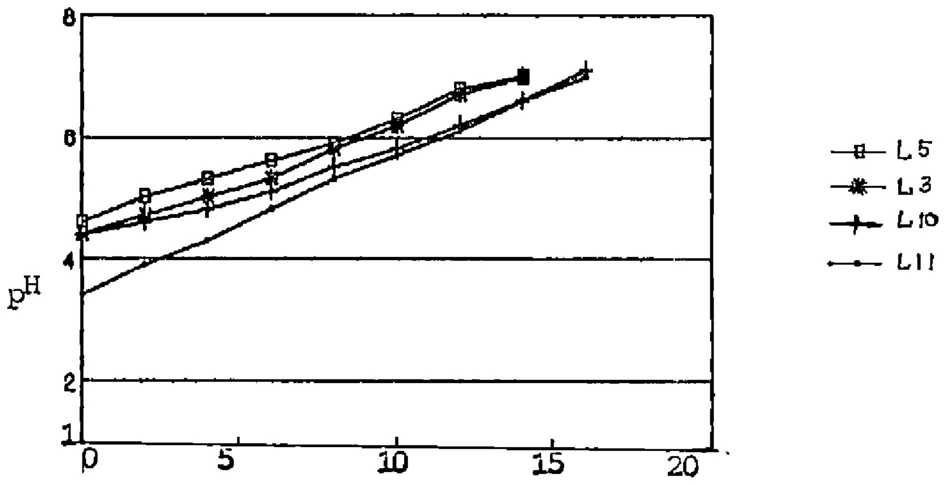
Qnty.of CaO applied to soil (t/ha)

Fig.1b. Buffer curves for Karappadam soils



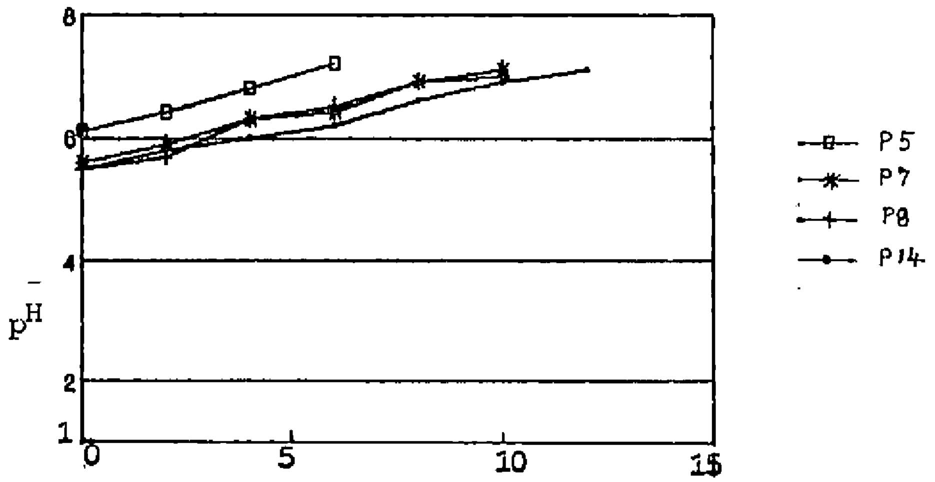
Qnty.of CaO applied to soil (t/ha)

Fig.1c. Buffer curves for Kayal soils



Qnty.of CaO applied to soil (t/ha)

Fig.1d. Buffer curves of Pattambi soils



Qnty. of CaO applied to soil (t/ha)

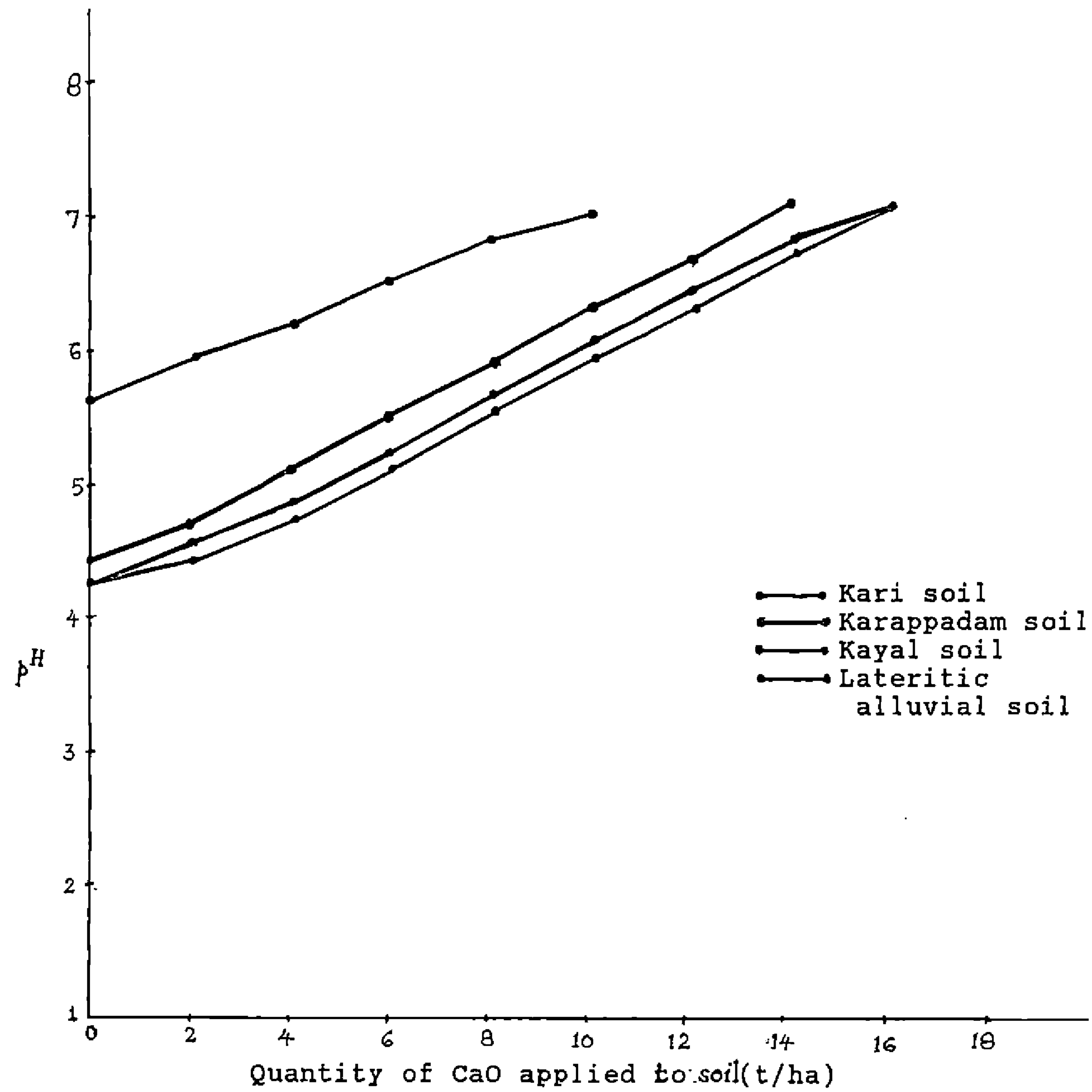


Fig.1e. Comparison of buffer curves of different wetland soil types

TABLE 3 GENERAL CHARACTERISTICS OF KAYAL SOILS

Sample	p^H	WHC (%)	CEC (Cmol Kg^{-1})	Total OM (%)	Lime Req. $t ha^{-1}$	Total N_2 (%)	Total P_2O_5 (%)	Total K_2O (%)	Total Ca (%)	Total Mg (%)	Avail. N_2 Kg ha^{-1}	Avail. P_2O_5 Kg ha^{-1}	Avail. K_2O Kg ha^{-1}	Exch. Ca (Cmol Kg^{-1})	Exch. Mg (Cmol Kg^{-1})
L1	4.1	80.8	18.1	8.59	32	0.42	0.154	0.32	0.60	0.13	468.4	0.56	419.3	5.46	2.11
L2	3.9	84.2	17.9	6.62	28	0.27	0.092	0.54	0.58	0.13	383.7	2.24	387.1	5.25	1.43
L3	4.4	75.4	21.7	7.97	32	0.33	0.183	0.34	0.56	0.19	443.3	0.01	510.7	5.36	1.38
L4	4.3	78.1	19.4	8.07	32	0.48	0.193	0.44	0.50	0.20	454.4	0.55	424.7	4.89	1.54
L5	4.3	70.2	15.7	7.76	32	0.26	0.191	0.48	0.64	0.20	437.9	1.12	387.1	8.79	2.58
L6	4.6	76.2	17.0	6.31	28	0.48	0.272	0.52	0.48	0.19	405.4	0.02	392.5	4.94	1.53
L7	4.2	77.2	19.1	6.52	28	0.27	0.198	0.46	0.60	0.21	373.0	2.22	381.7	5.46	2.60
L8	3.8	75.1	19.6	8.90	32	0.27	0.144	0.50	0.46	0.21	473.6	0.01	446.2	4.21	2.75
L9	3.9	93.1	20.0	11.28	32	0.42	0.119	0.36	0.42	0.12	556.8	1.11	338.7	2.96	1.30
L10	4.4	84.3	18.1	10.34	32	0.44	0.106	0.55	0.40	0.14	484.4	0.01	365.6	2.18	1.48
L11	3.4	84.2	16.3	10.76	32	0.32	0.082	0.37	0.64	0.13	196.5	0.55	48.4	3.33	1.27
L12	4.1	78.2	15.6	5.69	28	0.23	0.099	0.38	0.44	0.14	367.6	0.56	112.9	6.34	1.47
L13	4.6	82.0	18.0	8.07	32	0.18	0.131	0.54	0.46	0.10	454.4	0.03	510.7	3.07	1.41
L14	4.6	85.4	18.4	6.93	32	0.21	0.074	0.28	0.50	0.09	421.7	4.45	333.3	3.54	1.23
L15	4.1	87.6	16.7	6.62	28	0.24	0.099	0.24	0.56	0.12	405.5	8.96	317.1	4.84	1.17
Mean	4.2	80.8	18.1	8.03	30.7	0.32	0.143	0.42	0.52	0.15	441.8	1.49	358.4	4.71	1.68
C.V (%)	8.1	7.2	9.3	21.2	6.4	31.5	39.0	24.1	15.2	27.4	10.9	160.8	35.4	34.8	32.2

4.1.7. **Total Nitrogen**

As seen from table 5, in all the four soil types, the total nitrogen content showed a high degree of variability which amounts to 26.3% for lateritic alluvial soil and 35.4% for _Kari_ soils. In _Karappadam_ and _Kayal_ soils, total nitrogen content recorded a coefficient of variation of 28.4% and 31.5% respectively. The total nitrogen content ranged from 0.12- 0.50% in _Kari_, 0.18 - 0.50% in _Karappadam_, 0.18 - 0.48% in _Kayal_ and 0.14 - 0.30% in lateritic alluvial soils. Lateritic alluvial soils which had the lowest value for total nitrogen of 0.22% differed significantly from that of _Karappadam_ and _Kayal_ soils.

4.1.8. **Total Phosphorus**

As in the case of total nitrogen, total phosphorus also showed a high degree of variability within the soil types. _Kari_ and _Karappadam_ soils recorded lower values for total phosphorus and the average values are 0.044 and 0.077% respectively. On the other hand, _Kayal_ and lateritic alluvial soils contained significantly higher amounts of total phosphorus than the others and recorded an average content of 0.142 and 0.117% respectively, as seen from table 5.

TABLE 4 GENERAL CHARACTERISTICS OF LATERITIC ALLUVIAL SOILS OF PATTAMBI

Sample	p^H	WHC (%)	CEC (Cmol Kg^{-1})	Total OM(%)	Lime Req. tha^{-1}	Total N_2 (%)	Total P_2O_5 (%)	Total K_2O (%)	Total Ca (%)	Total Mg (%)	Avail. N_2 Kg ha^{-1}	Avail. P_2O_5 Kg ha^{-1}	Avail. K_2O Kg ha^{-1}	Exch. Ca (Cmol Kg^{-1})	Exch. Mg (Cmol Kg^{-1})
P1	5.7	49.6	5.2	1.45	20	0.17	0.098	0.06	0.07	0.03	356.8	8.96	75.3	2.34	0.13
P2	5.5	52.8	8.3	2.07	20	0.26	0.125	0.06	0.04	0.03	535.2	11.20	86.0	1.98	0.12
P3	5.7	54.4	7.4	1.76	20	0.15	0.130	0.05	0.12	0.02	448.7	11.20	155.9	3.33	0.14
P4	5.6	54.3	6.8	1.86	20	0.21	0.078	0.05	0.07	0.03	443.3	13.44	107.5	2.13	0.14
P5	6.1	43.8	4.8	1.45	12	0.14	0.093	0.03	0.13	0.02	297.3	33.60	75.3	2.24	0.13
P6	5.5	36.5	6.1	2.69	16	0.27	0.125	0.11	0.13	0.03	400.1	8.96	155.9	2.18	0.13
P7	5.7	42.8	6.7	1.66	20	0.18	0.118	0.10	0.09	0.03	351.5	26.88	112.9	1.92	0.15
P8	5.6	37.3	6.6	1.76	20	0.19	0.135	0.08	0.09	0.03	383.9	11.20	102.0	2.81	0.14
P9	5.5	51.6	9.7	3.41	20	0.30	0.160	0.09	0.09	0.03	443.3	190.40	112.9	2.76	0.15
P10	5.7	37.4	7.9	2.38	20	0.27	0.130	0.05	0.08	0.03	465.0	156.80	155.9	1.77	0.30
P11	5.7	42.1	7.1	2.59	20	0.30	0.113	0.06	0.09	0.03	535.1	35.84	145.2	1.82	0.14
P12	5.6	40.7	8.0	2.69	20	0.24	0.063	0.12	0.08	0.03	529.8	91.84	112.9	1.72	0.14
P13	5.4	46.8	8.3	3.10	24	0.30	0.130	0.05	0.08	0.03	378.6	31.36	123.7	2.81	0.14
P14	5.6	38.3	7.6	2.07	24	0.17	0.120	0.05	0.08	0.03	513.6	94.08	150.5	1.92	0.13
P15	5.7	38.1	4.3	2.59	20	0.17	0.138	0.07	0.09	0.03	427.2	85.12	102.1	4.11	0.14
Mean	5.6	44.4	7.0	2.24	19.7	0.22	0.117	0.07	0.09	0.03	434.0	54.06	118.3	2.39	0.15
C.V (%)	2.8	14.9	20.8	26.8	14.3	26.3	21.2	37.9	26.6	4.5	16.9	106.5	24.2	27.9	28.9

4.1.9. **Total Potassium**

From tables 1-4, it may be noted that all the four soil types are highly variable in their total potassium content. Kari soil showed maximum variability (C.V = 74.3%) and the total potassium content in these soils ranged from 0.05 to 0.60%. The total potassium in Karappadam, Kayal and lateritic alluvial soils ranged from 0.17 to 0.59%, 0.24 to 0.55% and 0.03 to 0.12% respectively. Among the four soil types, Kayal soils recorded the highest content of total potassium, to the tune of 0.42% and lateritic alluvial soils the lowest content of 0.07%. The Kayal and lateritic alluvial soils are significantly different from the other soil types in their average content of total potassium.

4.1.10. **Total Calcium**

In the case of total calcium also, Kayal soils topped the other soil types with a mean value of 0.52%, while lateritic alluvial soils recorded the lowest value which ranged from 0.04 to 0.13% with a mean value of 0.09%. Total calcium showed high degree of variability within each soil type and the average content of total calcium decreased from 0.52% in Kayal soils to 0.09% in lateritic alluvial soils. Kari and Karappadam soils showed intermediate values of 0.35 and 0.22% respectively. Between the four soil types, there exist a significant difference in the content of total calcium.

TABLE 5 PHYSICO-CHEMICAL PROPERTIES OF FOUR TYPES OF SOILS

SOIL PROPERTIES		Kari Soil	Karappadam Soil	Kayal Soil	Lateritic alluvial Soil	CD Values
p^H		4.2	4.4	4.2	5.6	0.2
WHC	(%)	69.3	71.8	80.8	44.4	5.8
CEC	(C mol Kg^{-1})	19.0	15.4	18.1	7.0	3.4
Total OM	(%)	7.58	6.81	8.03	2.24	1.77
Lime requirement	(t ha^{-1})	30.1	26.7	30.7	19.7	2.8
Total N_2	(%)	0.28	0.32	0.32	0.22	0.07
Total P_2O_5	(%)	0.044	0.077	0.143	0.117	0.025
Total K_2O	(%)	0.22	0.29	0.42	0.07	0.08
Total Ca	(%)	0.35	0.22	0.52	0.09	0.07
Total Mg	(%)	0.14	0.16	0.15	0.03	0.02
Available N_2	(kg ha^{-1})	469.9	421.6	441.8	434.0	-
Available P_2O5	(Kg ha^{-1})	3.29	5.12	1.49	54.06	21.29
Available K_2O	($Kgha^{-1}$)	236.2	164.9	358.4	118.3	70.1
Exchangeable Ca	(Cmol Kg^{-1})	3.56	3.82	4.71	2.39	0.83
Exchangeable Mg	(Cmol Kg^{-1})	1.42	1.11	1.68	0.15	0.23

4.1.11. Total Magnesium

Tables 1-4 reveal that the total magnesium in all the soil types except lateritic alluvial soils are highly variable. (C.V = 18.1% in Kari to 27.4% in Kayal soils). Lateritic alluvial soils are more uniform in their total magnesium content with an average value of 0.03% which is significantly lower than that in the other soils. The Kari, Karappadam and Kayal soils do not differ significantly in their total magnesium content and its ranges are o.10 to 0.18%, 0.10 to 0.26% and 0.09 to 0.21% in the respective soils.

4.1.12. Available Nitrogen

The average available nitrogen content in Kari, Karappadam, Kayal and lateritic alluvial soils are 469.9, 421.6, 441.8 and 434.0 Kg ha^{-1} respectively. These soils do not differ significantly in this parameter. The degree of variation in the status of available nitrogen in all the four soil types is much lower (10.9 to 19.7%) than that of other parameters presented above.

4.1.13. Available Phosphorus

Available phosphorus showed the maximum degree of variability in all the four soil types with the coefficient of variation ranging from 85% in Kari to 160.8% in Kayal soils. Available phosphorus recorded wide ranges of values and these are 0.01to 8.96 Kg ha^{-1} in Kari and Kayal soils, 0.02 - 31.36 kg ha^{-1} in Karappadam soils and 8.96 to 190.40 kg ha^{-1} in lateritic alluvial soils. All the samples of Kari, Karappadam and Kayal soils are very low in available phosphorus whereas the available phosphorus content in lateritic alluvial soils is significantly higher (mean = 54.06Kg ha^{-1}) than that in the other soil types.

4.1.14. Exchangeable Potassium, Calcium and Magnesium

Exchangeable potassium, calcium and magnesium also showed wide variations within each of the four soil types. The values of available potassium ranged between 53.8 and 430.1 kg ha^{-1} in Kari, 59.1 and 360.2 kg ha^{-1} in Karappadam, 48.4 and 510.7 kg ha^{-1} in Kayal and 75.3 and 155.9 kg ha^{-1} in lateritic alluvial soils. Among the four soil types, Kari and Kayal soils recorded significantly higher mean values for available potassium which amounts to 236.2 and 358.4 kg ha^{-1} respectively, when compared to that of Karappadam and lateritic alluvial soils with mean values 164.9 and 118.3 kg ha^{-1} respectively.

Among the four different soil types, exchangeable calcium in Kayal soil recorded a significantly higher value of 4.71 Cmol kg^{-1} whereas lateritic alluvial soils recorded a significantly lower value of 2.39 Cmol kg^{-1} only. Kari and Karappadam soils are with intermediate values of 3.56 and 3.82 Cmol kg^{-1} respectively.

In the case of exchangeable magnesium lateritic alluvial soils recorded the lowest average value of 0.15 Cmol kg^{-1} and Kayal soils the highest mean value of 1.68 Cmol kg^{-1}. The Kari and Karappadam soils are significantly different from other soil types in their available magnesium content and the average values are 1.42 and 1.11 Cmol kg^{-1} respectively.

4.2. SOIL PROPERTIES ASSOCIATED WITH SOIL ORGANIC MATTER

Soil properties such as pH, WHC, CEC, lime requirement and buffering capacity were determined in all the soil types after the destruction of organic matter. The mean values of relevant data are presented in tables 6a - 9a.

4.2.1. pH

Table 6-9 shows that the Kari and Kayal soils, which have an average pH value of 4.2, recorded an increase in pH by 0.2 and 0.7units respectively, due to the destruction of organic matter in them. The pH of Karappadam and lateritic alluvial soils with average values 4.4 and 5.6, also increased to 5.2 and 5.9 respectively. The contribution of SOM to pH value in Kari

TABLE 6a CONTRIBUTION OF ORGANIC MATTER TO SOIL PROPERTIES - KARI SOIL

Basic Characters		SOIL	After removal of SOM	Range of percentage contribution of SOM	Average percentage contribution of SOM
p^H		4.2	4.4	0.2-25.0	7.1
WHC	(%)	69.3	51.9	9.5-57.9	24.7
CEC	(Cmol Kg^{-1})	19.0	14.0	11.4-50.0	27.2
Lime requirement	(tha^{-1})	30.1	22.4	12.5-50.0	25.5

TABLE 6.b CONTRIBUTION OF ORGANIC MATTER TO NUTRIENTS IN SOIL - KARI SOIL

NUTRIENTS	Soil	Linked with SOM	Range of % contribution of SOM	Average % contribution of SOM
Total N_2 (%)	0.28	0.25	90.0-94.4	92.2
Total P_2O_5(%)	0.044	0.014	8.0-80.0	35.2
Total K_2O (%)	0.22	0.01	1.4-8.8	4.4
Total Ca (%)	0.35	0.03	1.3-16.4	7.7
Total Mg (%)	0.14	0.01	4.1-8.0	5.3
Available N_2 ($kgha^{-1}$)	469.9	435.6	90.2-93.9	92.5
Available P_2O_5 ($kgha^{-1}$)	3.29	0.99	1.1-79.9	27.7
Available K_2O ($kgha^{-1}$)	236.2	10.8	1.5-8.8	4.4
Exchangeable Ca (Cmol kg^{-1})	3.56	0.28	1.3-16.6	7.8
Exchangeable Mg (Cmol kg^{-1})	1.42	0.08	4.3-7.8	5.3

Karappadam, Kayal and lateritic alluvial soils comes to 7.1, 18.4, 17.2 and 4.2% respectively.

From tables 6a-9a, it may be seen that the maximum contribution to pH by organic matter is in Karappadam soils and the least in lateritic alluvial soils.

4.2.2. **WATER HOLDING CAPACITY**

WHC of all the soil samples showed a remarkable decrease due to the destruction of organic matter present in them. As seen from table 6a, in Kari soils, the average value of WHC, which is 69.3%, decreased to 51.9% on destruction of organic matter. The direct contribution of organic matter to WHC,ranged between 9.5 and 57.9% in the individual samples with an average value of 24.7%.

In the Karappadam soils (table 7a), the initial WHC of 71.8%, was reduced to 50.9% after destruction of organic matter. The average contribution of organic matter to the WHC in these soils comes to 29.4%.

The Kayal soils, which recorded a maximum WHC of 80.8% (table 8a), after destruction of organic matter registered a lower value of 60.2% indicating the average contribution of SOM to be about 25.3%.

TABLE 7a. CONTRIBUTION OF ORGANIC MATTER TO SOIL PROPERTIES - KARAPPADAM SOIL

Basic Characters		SOIL	After removal of SOM	Range of percentage Contribution of SOM	Average percentage contribution of SOM
PH		4.4	5.2	10.9-28.6	18.4
WHC	(%)	71.8	50.9	12.9-49.9	29.4
CEC	(Cmol kg^{-1})	15.4	12.2	2.8-35.0	19.6
Lime requirement	(t ha^{-1})	26.7	21.6	12.5-28.6	18.9

TABLE 7 b CONTRIBUTION OF ORGANIC MATTER TO NUTRIENTS IN SOIL - KARAPPADAM SOIL

Nutrients	Soil	Linked with SOM	Range of percentage contribution of SOM	Average percentage contribution of SOM
Total N_2 (%)	0.32	0.29	90.7-94.2	92.1
Total P_2O_5 (%)	0.077	0.007	1.6-22.1	9.8
Total K_2O (%)	0.29	0.01	0.9-2.5	1.5
Total C_a (%)	0.22	0.01	1.2-6.3	2.7
Total Mg (%)	0.16	0.003	0.8-11.3	2.1
Available N_2 ($kgha^{-1}$)	421.6	400.6	92.2-96.5	95.1
Available P_2O_5 ($kgha^{-1}$)	5.12	0.77	1.2-22.1	9.7
Available K_2O ($kgha^{-1}$)	164.9	4.8	0.9-7.7	2.3
Exchangeable C_a (Cmol kg^{-1})	3.82	0.24	4.1-9.3	6.4
Exchangeable Mg (Cmol kg^{-1})	1.11	0.10	0.7-13.2	8.6

The lateritic alluvial soils also behaved in the same way, where the original value of 44.4% showed nearly 50% reduction and has decreased to 22.4% due to the destruction of organic matter. This soil type showed an almost equal distribution of WHC contributed by the mineral matter and organic matter.

The maximum contribution of organic matter to WHC is shown by lateritic alluvial soils followed by Karappadam, Kayal and Kari soils.

4.2.3. CATION EXCHANGE CAPACITY

The average CEC of Kari soils which recorded a value of 19.0 Cmol kg^{-1} has dropped to 14.0 Cmol kg^{-1} after destruction of organic matter and the difference of 5.0 Cmol kg^{-1} is thus seen to be contributed by SOM. The contribution of SOM to CEC in these soils ranged between 11.4 and 50.0%, with an average of 27.2%.

From Table 7a, it may be seen that in Karappadam soils, the average value for CEC is 15.4 Cmol kg^{-1} in which the contribution by mineral matter is 12.2 Cmol Kg^{-1}. The average contribution of organic matter to total CEC in these soils comes to 19.6%.

In Kayal soils (table 8a), with an average CEC value of 18.1 Cmol kg^{-1}, the share of mineral matter is 16.4 Cmol kg^{-1}.

The percent contribution of SOM to CEC in these soils ranges between 4.6 and 28.3% with an average of 9.7%.

The lateritic alluvial soils (table 9a), with an average CEC of 7.0 Cmol kg^{-1} recorded a contribution of 16.8% of the total CEC from its organic matter.

From Tables 6a-9a, it may be seen that the maximum contribution of organic matter to CEC is evident in Kari soils, followed by Karappadam, lateritic alluvial and Kayal soils respectively.

4.2.4. LIME REQUIREMENT

As seen from table 6a, the average lime requirement of Kari soils, which is 30.1 t ha^{-1}, has decreased to 22.4 t ha^{-1} due to the destruction of organic matter. A decrease of 7.7 t ha^{-1} in the lime requirement of these soils is noted which is caused by SOM in the Kari soil. The quantity of lime required to neutralize the acidity contributed by SOM in this soil type ranged between 12.5 and 50.0% of the total lime requirement, with an average of 25.5%.

Karappadam soil with an original LR of 26.7 t ha^{-1}, showed a decrease of 5.1 t ha^{-1} which is equivalent to the acidity created by SOM alone. The LR of soils devoid of SOM corresponds to

TABLE 8a CONTRIBUTION OF ORGANIC MATTER TO SOIL PROPERTIES - KAYAL SOIL

Basic Characters		SOIL	After removal of SOM	Range of percentage contribution of SOM	Average percentage contribution of SOM
p^H		4.2	4.9	2.3-31.0	17.2
WHC	(%)	80.8	60.2	8.7-40.9	25.3
CEC	(Cmolkg-1)	18.1	16.4	4.6-28.3	9.7
Lime requirement	(t ha^{-1})	30.7	26.4	12.5-25.0	13.9

TABLE 8 b CONTRIBUTION OF ORGANIC MATTER TO NUTRIENTS IN SOIL - KAYAL SOIL

Nutrients	Soil	Linked with SOM	Range of percentage contribution of SOM	Average percentage contribution of SOM
Total N_2 (%)	0.32	0.30	90.3-96.2	94.3
Total P_2O_5 (%)	0.143	0.007	1.5-23.2	5.6
Total K_2O (%)	0.42	0.02	2.0-7.3	4.5
Total C_a (%)	0.52	0.01	0.7-2.1	1.0
Total Mg (%)	0.15	0.01	1.6-13.8	8.8
Available N_2 ($kgha^{-1}$)	441.8	399.1	90.0-92.6	91.1
Available P_2O_5 ($kgha^{-1}$)	1.49	0.15	1.5-30.4	7.6
Available K_2O ($kgha^{-1}$)	358.4	2.8	0.3-2.1	0.9
Exchangeable C_a (Cmol kg^{-1})	4.71	0.03	0.3-1.0	0.7
Exchangeable Mg (Cmol kg^{-1})	1.68	0.22	7.8-19.7	14.2

acidity created by mineral matter. As evidenced from table 7a, on an average 18.9% of the total LR in these soils is utilised to neutralize the acidity contributed by SOM.

AS seen from table 8a, the average value of LR in <u>Kayal</u> soils is 30.7 t ha^{-1} which has dropped to 26.4 t ha^{-1} due to the destruction of SOM. In these soils, on an average 13.9% of the total LR is required to neutralize the acidity derived from SOM.

The lateritic alluvial soils, as seen from table 9a, recorded an average LR of 19.7 t ha^{-1} of which 15.7 t ha^{-1} is required to neutralize the acidity residing on the mineral matter of soil. The remaining 4 t ha^{-1} of lime is required to neutralize the acidity generated by SOM. The amount of lime required to neutralize the acidity contributed by organic matter, is maximum in <u>Kari</u> soils and minimum in lateritic alluvial soils, as seen from tables 6a-9a.

4.2.5. **BUFFERING CAPACITY**

Buffering capacity of the four soil types before and after the destruction of SOM were estimated and is presented as curves shown in figures 2-5. From the buffer curves it may be seen that in all the four soil types, there is a reduction in buffering capacity, due to the destruction of organic matter. The maximum

Fig.2. Influence of SOM on buffering capacity - Kari soil

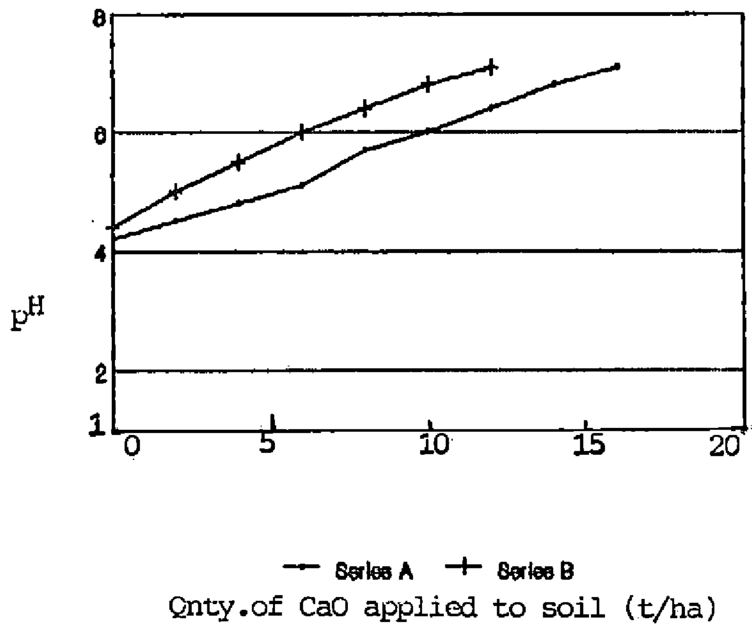
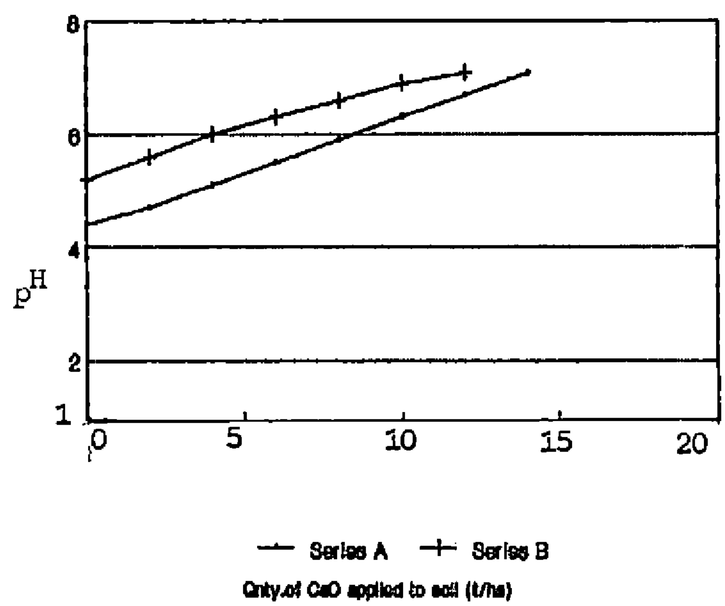


Fig.3. Influence of SOM on buffering capacity - Karappadam soil



Series A - Soils with SOM
Series B - Soils after removal of SOM

Fig.4. Influence of SOM on buffering capacity - Kayal soil

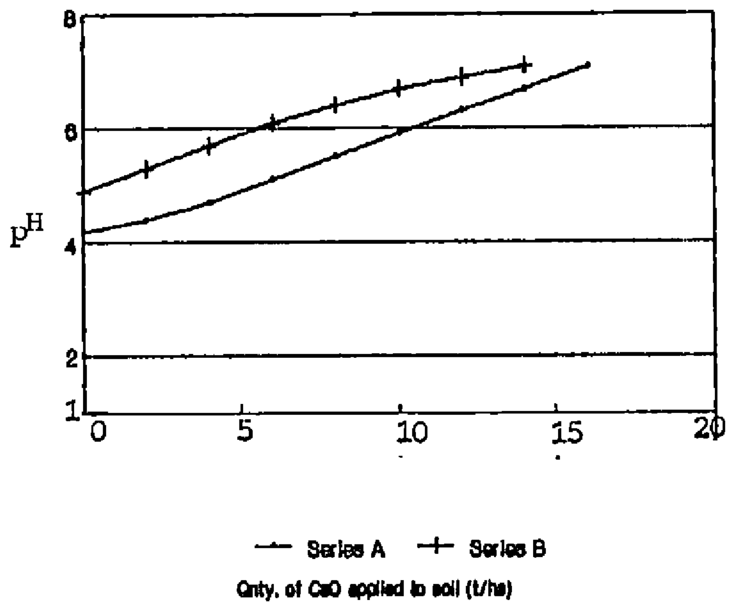
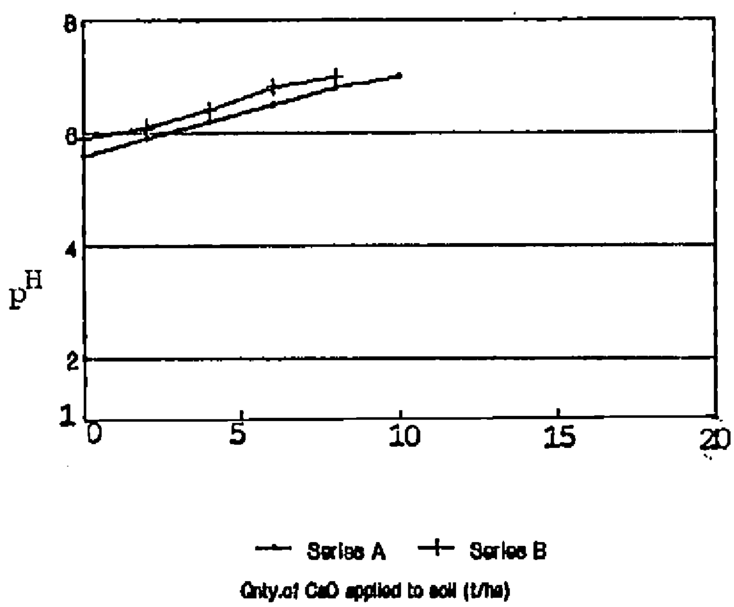


Fig.5. Influence of SOM on buffering capacity - Lateritic alluvial soil



Series A - Soils with SOM
Series B - Soils after removal of SOM

reduction in buffering capacity is noticed in Kari soil, while in the other three soil types, the pattern is more or less similar.

4.3. NUTRIENTS IN THE SOIL ASSOCIATED WITH ORGANIC MATTER

Total and available nitrogen, phosphorus, potassium, calcium and magnesium content of the soil samples after removal of organic matter were estimated and the results are presented in tables 6b - 9b.

4.3.1. TOTAL NITROGEN

From table 6b, it may be seen that the average content of total nitrogen in Kari soil which was originally 0.28%, after destruction of organic matter has decreased to 0.03%. The reduction in total nitrogen content ranged from 90.0 to 94.4% in this soil, the average being 92.2%. The remaining part of nitrogen only is directly linked with soil mineral matter.

As evidenced from table 7b, the Karappadam soils contained on an average 0.32% nitrogen, out of which 0.29% is contributed by SOM. The average contribution of organic matter to total nitrogen in these soils amounts to 92.1%.

In the Kayal soils, which recorded a total nitrogen content of 0.32%, the contribution of organic matter ranged from 90.3 to

TABLE 9a CONTRIBUTION OF ORGANIC MATTER TO SOIL PROPERTIES - LAT.ALL. SOIL

Basic Characters		SOIL	After removal of SOM	Range of percentage contribution of SOM	Average percentage contribution of SOM
p^H		5.6	5.9	1.6-5.6	4.2
WHC	(%)	44.4	22.4	32.3-65.9	49.8
CEC	(Cmolkg-1)	7.0	5.8	1.4-35.4	16.8
Lime requirement	($t\ ha^{-1}$)	19.7	15.7	16.7-33.3	20.8

TABLE 9 b CONTRIBUTION OF ORGANIC MATTER TO NUTRIENTS IN SOIL - LAT.ALL. SOIL

Nutrients	Soil	Linked with SOM	Range of percentage contribution of SOM	Average percentage contribution of SOM
Total N_2 (%)	0.22	0.20	90.4-92.9	91.0
Total P_2O_5 (%)	0.117	0.011	2.2-36.5	10.4
Total K_2O (%)	0.07	0.01	0.9-68.8	7.4
Total C_a (%)	0.09	0.01	0.8-13.3	2.5
Total Mg (%)	0.03	0.003	3.5-7.7	4.8
Available N_2 ($kgha^{-1}$)	434.0	400.5	90.1-93.7	92.4
Available P_2O_5 ($kgha^{-1}$)	54.06	8.11	2.3-36.4	11.1
Available K_2O ($kgha^{-1}$)	118.3	4.7	0.9-12.4	3.8
Exchangeable C_a ($Cmol\ kg^{-1}$)	2.39	0.08	0.9-6.6	3.3
Exchangeable Mg ($Cmol\ kg^{-1}$)	0.15	0.01	1.2-8.3	4.3

96.2%, with an average of 94.3%, as seen from table 8b. The lateritic alluvial soils recorded a total nitrogen content of 0.22% where 90.4 to 92.9% of it is associated with organic matter.

From tables 6b-9b, it may be seen that the maximum contribution of SOM to total nitrogen is seen in Kayal soils followed by Kari, Karappadam and lateritic alluvial soils.

4.3.2. **AVAILABLE NITROGEN**

From table 6b, it is seen that the average content of available nitrogen in Kari soils which is 469.9 kg ha^{-1} has decreased to 34.3 kg ha^{-1} on destruction of OM. This reduction of 435.6 kg ha^{-1} which amount to 92.5% of the available nitrogen is the quantity of nitrogen that is linked with SOM. The contribution of SOM to available nitrogen in these soils ranges from 90.2 to 93.9%.

In the Karappadam soils, the available nitrogen content of 421.6 kg ha^{-1} is reduced to 21.0 kg ha^{-1} after the destruction of SOM. This part alone is associated with the mineral fraction of the soil as against the remaining 95.1% which is bound with SOM.

The *Kayal* soils, as seen from table 8b, recorded an average available nitrogen content of 441.8 kg ha^{-1} out of which 399.1 kg ha^{-1} is linked with organic matter. The contribution of SOM to available nitrogen, in these soils ranges between 90.0 and 92.6%, with an average of 91.1%.

As seen from table 9b, in lateritic alluvial soils, the available nitrogen content of 434.0 kg ha^{-1} has decreased to 33.5 kg ha^{-1} on destruction of OM. The average contribution of organic matter is 92.4% of the available nitrogen in these soils.

It may be seen that the maximum contribution of organic matter to available nitrogen is made in the *Karappadam* soils. The *Kari*, *Kayal* and lateritic alluvial soils recorded lower values for percentage contribution of organic matter to available nitrogen content.

4.3.3. TOTAL PHOSPHORUS

In the *Kari* soils, the total phosphorus content which has recorded an average value of 0.044%, decreased to 0.030% on destruction of organic matter. On an average, this drop in total phosphorus content which is the share contributed by organic matter amounts to 35.2% of the total phosphorus. The *Kari* soil seems to hold the highest proportion of total phosphorus in organic form.

Data presented (table 7b) reveal that in the _Karappadam_ soils with an average total phosphorus content of 0.077%, the organic matter contributed 0.007%, which accounts for only 9.8% of the total phosphorus content.

In _Kayal_ soils, as seen from table 8a, the total phosphorus content is 0.143% out of which, 0.136% is associated with mineral matter. The contribution of organic matter to total phosphorus in these soils is relatively low and ranged between 1.5 and 23.2% with an average of 5.6% indicating the predominance of inorganic forms of total phosphorus in this soil type.

The average total phosphorus content in lateritic alluvial soils (table 9b), which is 0.117%, decreased to 0.106%, on destruction of organic matter. This reduction in total phosphorus, which accounts for the contribution of organic matter, ranged between 2.2 and 36.5% of the total phosphorus. Here also the inorganic phosphorus is much higher than organically bound phosphorus.

It may be seen that the organically bound fraction of total phosphorus is maximum in _Kari_ soils followed by lateritic alluvium, _Karappadam_ and _Kayal_ soils.

4.3.4. **AVAILABLE PHOSPHORUS**

The available phosphorus content, which registered average value of 3.29 kg ha^{-1} in Kari soils decreased to 2.30 Kg ha^{-1}, on destruction of SOM. This reduction in available phosphorus which is the contribution of SOM ranged between 1.1 and 79.9%, as seen in table 6b.

It may be seen that in Karappadam soils (table 7b), the average value for available phosphorus which was 5.12 kg ha^{-1}, dropped to 4.35 kg ha^{-1}, after destruction of organic matter. The percentage contribution of organic matter to the available phosphorus content in these soils ranged between 1.2 and 22.1% with an average of 9.7%.

In Kayal soils, the available phosphorus content which was originally 1.49 kg ha^{-1} is reduced to 1.34 kg ha^{-1}. The difference of 0.15 kg ha^{-1} is contributed by organic matter. In these soils the average contribution of organic mater is 7.6% of the available phosphorus content.

The lateritic alluvial soils recorded an average available phosphorus content of 54.06 kg ha^{-1} of which 8.11 kg ha^{-1} is contributed by organic matter and the share of organic matter to available phosphorus in these soils ranged between 2.3 and 36.4% with an average of 11.1%

The proportion of available phosphorus bound to organic matter is also maximum in _Kari_ soils, followed by lateritic alluvium, _Karappadam_ and _Kayal_ soils.

4.3.5. TOTAL POTASSIUM

From table 6b, it is seen that the total potassium in _Kari_ soils which registered an average value of 0.22% has decreased to 0.21% on destruction of organic mater. This reduction in total potassium which is the contribution of OM is appreciably low and account for only 1.4 to 8.8% of the total potassium with an average of 4.4% . In _Karappadam_ soils which has an average total potassium of 0.29%, destruction of organic matter has not caused any change indicating the presence of only very little organically bound potassium.

On destruction of organic matter in _Kayal_ soils, the average value for total potassium is reduced from 0.42 to 0.40%, again indicating a meagre association of total potassium with organic matter.

Lateritic alluvial soils, with an average total potassium content of 0.07%, showed a decline in total potassium content to 0.06%. This reduction, which amounts to an average of 7.4% is highly variable among individual soils, where it ranges between 0.9 and 68.8%

The organically bound portion of total potassium is maximum in lateritic alluvial soils (7.4%) and minimum in the Karappadam soils (1.5%).

4.3.6. AVAILABLE POTASSIUM

From tables 6b - 9b, it may be seen that the contribution of organic matter to available potassium is very low in all the four soil types. It is maximum in Kari soils with 4.4%, followed by Pattambi soils with 3.8% and Karappadam soils with 2.3%. Kayal soils registered the lowest value for available potassium bound in organic matter, which amounts to only 0.9%.

4.3.7. TOTAL AND EXCHANGEABLE CALCIUM

As in the case of available potassium, total and exchangeable calcium also showed a meagre association with organic matter. Kari soils recorded the maximum value for percentage contribution of organic matter to total and exchangeable calcium, both registering almost similar values (7.7%). The lowest percent contribution of organic matter to total and exchangeable calcium was seen in Kayal soils with values 1.0 and 0.7%. In lateritic alluvial and Karappadam soils, the values are intermediate being 2.5 and 3.3%, and 2.7 and 6.4% respectively for total and exchangeable calcium.

4.3.8. TOTAL AND EXCHANGEABLE MAGNESIUM

The average contribution of organic matter to total magnesium was maximum in Kayal soils (8.8%) followed by Kari (5.3%), lateritic alluvium (4.8%) and Karappadam soils (2.1)%.

In the case of exchangeable magnesium also the average contribution of organic matter is maximum in Kayal soil (14.2%) followed by Karappadam (8.6%), Kari (5.3%) and lateritic alluvial soils (4.3%).

4.4. SOIL ORGANIC MATTER AND ITS FRACTIONS

Kari, Karappadam and Kayal soils are rich in organic matter and the average organic matter content in these soils are 7.58, 6.81 and 8.03% respectively. On the other hand, the lateritic alluvial soils of Pattambi contained only 2.24% organic matter. The organic matter was separated into different fractions, viz. humified organic matter and non humified organic matter. Humified organic matter was further divided into humic acid and fulvic acid, based on their solubility in alkali, and acid. The humic acid to fulvic acid ratio (HA:FA) was also determined. Data on the distribution and ranges of different fractions of organic matter expressed as a percentage of soil as well as of SOM are presented in tables 10 - 11.

TABLE - 10 DISTRIBUTION OF SOM AND ITS FRACTIONS IN SOILS

OM and its fractions in Soil (as percentage to soil)		Kari Soils	Karappadam Soils	Kayal Soils	Lat.allu. Soils	CD Values
Total organic matter (%)						
	Range	1.83 - 12.31	2.91-11.79	5.69-11.28	1.45-3.41	
	Mean	7.58	6.81	8.03	2.24	1.77
	C.V (%)	44.70	43.50	21.20	26.80	
Non-humified organic matter (%)						
	Range	0.37 - 7.83	0.75 - 3.31	1.93 - 4.28	0.55 - 1.71	
	Mean	3.32	1.85	3.17	1.05	0.95
	C.V (%)	69.30	50.40	20.80	35.90	
Humified organic matter (%)						
	Range	1.46 - 7.56	2.04-8.48	3.76-7.00	0.87-2.01	
	Mean	4.26	4.96	4.86	1.19	1.03
	C.V (%)	35.60	42.22	22.10	25.69	
Humic acid (%)						
	Range	0.78 - 3.96	1.02-4.22	1.68-3.24	0.34-0.93	
	Mean	2.14	2.46	2.27	0.55	0.51
	C.V (%)	36.30	42.00	22.90	29.70	
Fulvic acid (%)						
	Range	1.28 - 3.9	1.02-4.26	1.96-3.76	0.46-1.08	
	Mean	2.12	2.50	2.59	0.64	0.53
	C.V (%)	36.80	42.40	21.80	25.00	
HA/FA ratio						
	Range	0.94 - 1.15	0.94-1.06	0.81-0.98	0.54-1.13	
	Mean	1.01	0.99	0.87	0.86	0.07
	C.V (%)	5.20	3.30	6.20	19.50	

TABLE 11 FRACTIONS OF SOM (As percentage of SOM-Mean values)

Fractions of SOM (%)	Kari Soil	Karappadam Soil	Kayal Soil	Lat.allu. Soil
Non humified organic matter	43.80	27.20	39.60	46.90
Humified organic matter	56.20	72.80	60.40	53.10
Humic acid	28.20	36.10	28.40	24.60
Fulvic acid	28.00	36.70	32.00	28.50

4.4.1. NON HUMIFIED ORGANIC MATTER

From tables 10-11, it may be seen that the non humified organic matter is low in all soil types. It varied widely and ranged from 0.37 to 7.83% in Kari, 0.75 to 3.31% in Karappadam, 1.93 to 4.28% in Kayal and 0.55 to 1.71% in lateritic alluvial soils. Maximum degree of variability in non-humified organic matter was shown by Kari soils with a C.V. of 69.3%, followed by Karappadam (50.4%), lateritic alluvium (35.9%) and Kayal soils (20.79%) respectively. Karappadam and lateritic alluvial soils recorded significantly lesser quantities of non humified organic matter than that recorded by Kari and Kayal soils. Of the total organic matter, the non humified fraction accounted to about 43.8% in Kari, 27.2% in Karappadam, 39.6% in Kayal and 46.9% in lateritic alluvial soils. The maximum contribution of non humified organic matter to total organic matter is seen in lateritic alluvial soils followed by Kari, Kayal and Karappadam soils.

4.4.2. HUMIFIED ORGANIC MATTER

In general, Kari, Karappadam and Kayal soils are rich in humified organic matter. The average content of humified organic matter in these soils are 4.26, 4.96 and 4.86% respectively, which accounted for 56.2%, 72.8% and 60.4% of the total organic matter. At the same time, lateritic alluvial soils contained the lowest quantity of humified organic matter, with an average content of 1.19%, which accounted for 53.1% of total organic matter. As seen from tables 10-11, all the four soil types are highly variable with regard to their status of humified organic matter. The coefficient of variation was maximum in <u>Karappadam</u> soils (42.22%) and it decreased in the order <u>Kari</u> (35.60%), followed by lateritic alluvium (25.69%) and <u>Kayal</u> (22.10%) soils.

It may be seen that the content of humified organic matter in lateritic alluvial soils is only one fourth of the same found in other soils and as in the case of total organic matter humified organic matter was also significantly lower in these soils.

From table 11, it may be seen that the humified fraction of SOM, is maximum in <u>Karappadam</u> soils, followed by <u>Kayal</u> and <u>Kari</u> soils. The lateritic alluvial soils recorded the lowest value.

4.4.3 HUMIC ACID (HA)

Humic acid is the fraction of SOM, soluble in alkali and insoluble in acid. HA content of humus ranged from 0.78 to 3.96% in <u>Kari</u>, 1.02 to 4.22% in <u>Karappadam</u>, 1.68 to 3.24% in <u>Kayal</u>, and 0.34 to 0.93% in lateritic alluvial soils. This accounts for

28.2, 36.1, 28.4 and 24.6% of the total SOM in the respective soils. All these soils showed a high degree of variability in their HA content. On an average Karappadam soils registered the highest quantity of HA, ie 2.46%, followed by Kayal and Kari soils with 2.27 and 2.14% respectively.

From table 10, it is evident that lateritic alluvial soils are significantly lower in HA content than the other three soil types.

4.4.4. **FULVIC ACID (FA)**

Fulvic acid is the fraction of humified OM soluble in both alkali and acid. FA showed a wide range of values in all the four soil types. The values ranged between 1.28 and 3.9% in Kari, 1.02 and 4.26% in Karappadam, 1.96 and 3.76% in Kayal and 0.46 and 1.08% in lateritic alluvial soils. On an average, the FA content in these soils are 2.12, 2.50, 2.59 and 0.64% respectively which account for 28.0, 36.7, 32.0 and 28.5% of the total OM.

Among the four soil types, maximum degree of variability is shown by Karappadam soil (C.V. = 42.4%) followed by Kari and lateritic alluvial soils. The Kayal soils showed the least variability of 21.8%. Kari, Karappadam and Kayal soils recorded significantly higher values for FA than lateritic alluvial soils.

The contribution of FA to total OM is maximum in Karappadam soils followed by Kayal, lateritic alluvial and Kari soils.

4.4.5. HA / FA RATIO

Humic acid / fulvic acid ratio is an index of the degree of degradation of humic substances. In Kari soils, the HA /FA ratio ranged from 0.94 to 1.15 and in Karappadam and Kayal soils, the ranges are 0.94 to 1.06 and 0.81 to 0.98 respectively. Lateritic alluvial soils recorded a wide range of HA /FA values which varied between 0.54 and 1.13. Among the four soil types, only in the case of Kari soil, the HA/FA value exceeded unity . In all the other soils HA/FA ratio is less than unity.

4.5. CORRELATION OF SOM AND ITS FRACTIONS WITH SOIL PROPERTIES

When all the 60 samples of soils, representing Kari Karappadam, Kayal and lateritic alluvial soils of Pattambi were taken together (table 12) almost all soil properties like WHC (r=0.6777), CEC (r=0.8373), lime requirement (r=0.6340), total and available nitrogen, potassium, calcium and magnesium showed a significant and positive relationship with SOM and its fractions. Total phosphorus showed a positive relationship which was not significant. pH showed a significant and negative relationship with SOM (r= -0.7962) and its fractions. However , the properties

Table 12 Correlation of Soil properties with SOM and its fractions in the four wetland soil types

Soil Properties	Total organic matter	Humified OM.	HA	FA	Non-humified OM
PH	-0.7962**	-0.7888**	-0.7923**	-0.7837**	-0.6353**
WHC	0.6777**	0.6720**	0.6559**	0.6774**	0.5400**
CEC	0.8373**	0.8140**	0.8170**	0.8132**	0.6895**
Lime requirement	0.6340**	0.5644**	0.5588**	0.5630**	0.5901**
Total N_2	0.4707**	0.4734**	0.4637**	0.4780**	0.3649**
Total P_2O_5	0.1569	0.1695	0.2216	0.1213	0.1062
Total K_2O	0.7045**	0.7203**	0.6973**	0.7412**	0.5333**
Total Ca	0.5692**	0.5045**	0.4689**	0.5272**	0.5330**
Total Mg	0.6527**	0.7075**	0.7021**	0.7004**	0.4406**
Available N_2	0.2552*	0.1220	0.1430	0.1009	0.2605*
Available P_2O_5	-0.4156**	-0.4482**	-0.4396**	-0.4520**	-0.2837*
Available K_2O	0.4956**	0.4153**	0.3797**	0.4393**	0.4960**
Exchangeable Ca	0.3801**	0.3464**	0.3238**	0.3623**	0.3435**
Exchangeable Mg	0.6855**	0.683**	0.6668**	0.6930**	0.5414**

r (d.f = 58) = 0.255 (5%)
0.331 (1%)

* - Significant at 5% level
** - Significant at 1% level

of individual soil types showed much difference in their degree of correlation with SOM which although positive, was not significant in some case as seen from tables 13-16.

The inter relationship between soil properties and SOM and its fractions in individual soils types are presented in tables 13-16.

In Kari soils (table 13) properties such as pH, WHC and CEC are significantly correlated with soil organic matter and its fractions.pH showed a significant negative correlation with soil organic matter (r = -0.6713) and its humified and non humified components and also with the humic acid and fulvic acid fractions of humified organic matter. Water holding capcity is significantly and positively correlated with soil organic matter (r = 0.5165). The relationship between WHC and the fractions of SOM, though positive was not significant. Cation exchange capcity registered a significant positive correlation with SOM (r = 0.6412), its humified fraction and also with the humic acid and fulvic acid components of humified organic matter.

Among the nutrients in Kari soil, total potassium, total and exchangeable magnesium, and available phosphorus registered significant correlation with soil organic matter and its components.Total potassium is significantly and positively

TABLE 13 CORRELATION OF SOIL PROPERTIES WITH SOM AND ITS FRACTIONS - KARI SOILS

Soil Properties	Total organic matter	Humified OM	HA	FA	Non-humified OM
p^H	-0.6713**	-0.6666**	-0.6961**	-0.6669**	-0.5501*
WHC	0.5165*	0.3332	0.3169	0.3185	0.5271*
CEC	0.6412**	0.7337**	0.7336**	0.7444**	0.4615
Lime requirement	0.4484	0.3989	0.3678	0.3942	0.3980
Total N_2	0.4887	0.3380	0.3419	0.3276	0.4975
Total P_2O_5	0.4320	0.4055	0.4086	0.3858	0.3695
Total K_2O	0.5117	0.4902	0.5239*	0.4849	0.4311
Total C_a	0.1161	0.3542	0.3912	0.3435	0.0625
Total Mg	0.6434**	0.6266*	0.6147*	0.6361*	0.5353*
Available N_2	0.4829	0.4563	0.4159	0.4595	0.4110
Available P_2O_5	-0.5823*	-0.3768	-0.3914	-0.3518	-0.6112*
Available K_2O	0.1397	0.0599	0.0753	0.0754	0.2455
Exchangeable Ca	0.4772	0.2561	0.2480	0.2432	0.5346*
Exchangeable Mg	0.4650	0.5498*	0.5521*	0.5466*	0.3230

r (d.f = 13) = 0.514 (5%)
0.641 (1%)

** - Significant at 1% level
* - Significant at 5% level

correlated only with the humic acid fraction of soil organic matter (r = 0.5239). Total magnesium is significantly and positively correlated with soil organic matter and also with all its components whereas the positive correlation of exchangeable magnesium is significant only with the humified fraction of organic matter (r = 0.5498) and humic acid and fulvic acid. Available phosphorus showed significant negative correlation with soil organic matter (r = -0.5823) and its non humified fraction.

In Karappadam soils (table 14), pH and CEC showed significant correlations with soil organic matter and its components which is positive for CEC and negative for pH. CEC registered significant positive correlation with SOM (r = 0.8582) and its components, while the negative correlation of pH is significant with soil organic matter (r = -0.5215) and its non humified fraction.

Among the nutrients in this soil type, total and available potassium, total calcuim and exchangeable magnesium showed significant correlation with SOM and all its components. The correlation coefficients of SOM with total potassium, available potassium, total calcuim and with exchangeable magnesium are 0.8085, 0.6690, 0.5842 and 0.6588 respectively.

Table 14 Correlation of Soil properties with SOM and its fractions - Karappadam Soils

Soil Properties	Total organic matter	Humified OM	HA	FA	Non-humified OM
p^H	-0.5215*	-0.4634	-0.4644	-0.4629	-0.6175*
WHC	0.0194	0.0642	0.0544	0.0737	0.0829
CEC	0.8582**	0.8488**	0.8485**	0.8485**	0.8488**
Lime requirement	0.0330	0.0257	0.0213	0.0300	0.1670
Total N_2	0.0785	0.1428	0.1361	0.1492	0.0809
Total P_2O_5	0.3308	0.3182	0.3170	0.3192	0.3333
Total K_2O	0.8085**	0.8330**	0.8351**	0.8305**	0.7059**
Total Ca	0.5842*	0.5327*	0.5300*	0.5350*	0.6657**
Total Mg	0.1725	0.1564	0.1471	0.1654	0.1990
Available N_2	0.3262	0.3368	0.3404	0.3330	0.2833
Available P_2O_5	-0.2683	-0.2322	-0.2252	-0.2389	-0.3358
Available K_2O	0.6690**	0.6424**	0.6426**	0.6418**	0.6938**
Exchangeable Ca	0.1869	0.2332	0.2017	0.2045	0.1309
Exchangeable Mg	0.6588**	0.6926**	0.6883**	0.6964**	0.5334*

r (d.f = 13) = 0.514 (5%)
0.641 (1%)

** - Significant at 1% level
* - Significant at 5% level

TABLE 15 CORRELATION OF SOIL PROPERTIES WITH SOM AND ITS FRACTIONS - KAYAL SOILS

Soil Properties	Total organic matter	Humified OM	HA	FA	Non-humified OM
p^H	-0.4313	-0.4448	0.4436	-0.4393	-0.3863
WHC	0.3995	0.3488	0.3947	0.3016	0.4608
CEC	0.2785	0.2599	0.2376	0.2765	0.2939
Lime requirement	0.0798	0.1162	0.0998	0.1296	0.0163
Total N_2	0.3937	0.4379	0.4127	0.4545	0.3009
Total P_2O_5	0.2489	0.2089	0.2632	0.1559	0.3309
Total K_2O	0.0416	0.0354	0.0249	0.0902	0.0496
Total Ca	0.1605	0.1663	0.1348	0.1927	0.1424
Total Mg	0.1835	0.1381	0.1826	0.0952	0.2477
Available N_2	0.9538**	0.9465**	0.9341**	0.7442**	0.7354**
Available P_2O_5	-0.3534	-0.4158	0.3349	-0.4838	-0.2330
Available K_2O	0.0881	0.1246	0.1671	0.0837	0.0239
Exchangeable Ca	-0.5581*	-0.4794	0.5164*	-0.4384	-0.6565**
Exchangeable Mg	0.0744	0.0817	0.1113	0.0533	0.0586

r (d.f = 13) = 0.514 (5%)
0.641 (1%)

** - Significant at 1% level
* - Significant at 5% level

TABLE 16 CORRELATION OF SOIL PROPERTIES WITH SOM AND ITS FRACTIONS - LAT. ALLU. SOILS

Soil Properties	Total organic matter	Humified OM	HA	FA	Non-humified OM
pH	-0.6058*	-0.5902*	0.5993*	-0.5163*	-0.4857
WHC	0.1255	0.1178	0.0355	0.1892	0.2945
CEC	0.5442*	0.5284*	0.5275*	0.4717	0.4378
Lime requirement	0.3075	0.0418	0.1609	0.0846	0.4547
Total N_2	0.7994**	0.6771**	0.7199**	0.5596*	0.7231**
Total P_2O_5	0.3838	0.3993	0.3030	0.4544	0.2873
Total K_2O	0.3847	0.4940	0.4507	0.4846	0.2121
Total C_a	0.0455	0.0857	0.0346	0.1286	0.1414
Total Mg	0.0316	0.1319	0.1465	0.1026	0.0562
Available N_2	0.3700	0.1725	0.3394	0.0170	0.4484
Available P_2O_5	0.5804*	0.4727	0.5493*	0.3430	0.5402*
Available K_2O	0.3608	0.2028	0.3169	0.0640	0.4093
Exchangeable Ca	0.1322	0.1337	0.1184	0.1347	0.1020
Exchangeable Mg	0.1261	0.0506	0.0312	0.1288	0.2411

r (d.f = 13) = 0.514 (5%)
0.641 (1%)

** - Significant at 1% level
* - Significant at 5% level

In _Kayal_ soils (table 15) properties such as WHC, CEC and lime requirment showed a positive and pH a negative correlation with SOM and its components. Among the nutrients, available nitrogen and exchangeable calcium are significantly correlated with SOM and its fractions. The positive correlation of available nitrogen is significant with SOM (r = 0.9538) as well as with all its components. The exchangeable calcuim is significantly and negatively correlated with SOM (r = -0.5581) as well as with humic acid and non humified fractions.

In lateritic alluvial soils (table 16) properties like pH and CEC are significantly correlated with SOM and its fractions. pH showed negative relationship with SOM (r = -0.6058) as well as with all its components except non humified fraction. CEC is significantly and positively correlated with SOM (r = 0.5442), humified and humic acid fractions. Among the nutrients, total nitrogen, and available phosphorus are significantly related to SOM and its components. Total nitrogen is significantly and positively related to SOM (r = 0.7994) and with all its fractions, while available phosphorus is significantly and positively related to SOM (r = 0.5804), humic acid and non humified fractions only.

4.6. INTERRELATIONSHIPS OF SOIL PROPERTIES WITH SOM AND ITS FRACTIONS

Regression analysis was carried out and equations were derived (table 17) to establish the precise relationship between various soil properties and SOM and its fractions. When all the four wetland soil types were taken together, almost all soil properties, viz. pH, WHC, CEC, lime requirement, total nitrogen, available phosphorus and total and exchangeable potassium, calcium and magnesium showed significant linear relationship with SOM and its fractions. However, when the individual soil types are considered separately, (table 18a-18d) only certain soil properties showed a linear relationship with SOM and its fractions.

In _Kari_ soils, (table 18a) properties such as pH, WHC, CEC available phosphorus and total and exchangeable magnesium showed significant linear relationship with SOM and its fractions. In _Karappadam_ soils (table 18b), pH, CEC, total and available potassium, total calcium and exchangeable magnesium are linearly related with SOM and its fractions. In _Kayal_ soils, as presented in table 18c, available nitrogen and exchangeable calcium alone are linearly related with SOM and its fractions. In lateritic alluvial soils (table 18d) pH, CEC, total nitrogen and available

TABLE - 17 RELATIONSHIP BETWEEN SOIL PROPERTIES AND SOIL ORGANIC MATTER AND ITS FRACTIONS IN WETLAND SOILS

Soil Properties	Total Organic matter (%) C	Humified OM (%) M	Humic acid (%) H	Fulvic acid (%) F
p^H	5.5941-0.1632 C **	5.5749-0.2585 M **	5.5589-0.5231 H **	5.5763-0.5023 F **
WHC	46.916+3.192 C **	47.275+5.060 M **	48.121+9.952 H **	46.965+9.976 F **
CEC	4.611+1.664 C **	4.996+2.586 M **	5.162+5.229 H **	4.928+5.052 F **
Lime reqrmt.	20.06+1.093 C **	20.86+1.556 M **	21.04+3.104 H **	20.83+3.036 F **
Total N_2	0.2011+0.0136 C **	0.2014+0.0219 M **	0.2048+0.0431 H **	0.1999+0.0432 F **
Total K	0.0294+0.0359 C **	0.0267+0.0587 M **	0.0383+0.1144 H **	0.0183+0.1181 F **
Total Ca	0.0997+0.0317 C **	0.1236+0.0450 M **	0.1390+0.0842 H **	0.1145+0.0919 F **
Total Mg	0.0443+0.0124 C **	0.0387+0.0215 M **	0.0410+0.0428 H **	0.0382+0.0419 F **
Available P_2O_5	43.80-4.513 C **	45.69-7.781 M **	44.52-15.381 H **	46.17-15.35 F **
Available K_2O	99.13+19.52 C **	119.61+26.16 M **	130.05+48.17 H **	113.02+54.11 F **
Exchangeable Ca	2.639+0.1590 C **	2.734+0.2316 M **	2.809+0.4362 H **	2.686+0.4737 F **
Exchangeable Mg	0.2514+0.1358 C **	0.2624+0.2165 M **	0.2988+0.4256 H **	0.2440+0.4294 F **

** - Significant at 1% level

* - Significant at 5% level

TABLE 18 RELATIONSHIP BETWEEN SOIL PROPERTIES AND ORGANIC MATTER AND ITS FRACTIONS IN DIFFERENT SOIL TYPES

a. KARI SOILS

Soil Properties	Total Organic matter C	Humified OM (%) M	Humic acid (%) H	Fulvic acid (%) F
p^H	4.685-0.070 C**	4.818-0.156 M**	4.837-0.316 H**	4.796-0.301 F**
WHC	59.00+1.36 C*	60.79+2.00 M*	61.38+3.70 H*	61.44+3.70 F*
CEC	8.79+1.35 C**	4.30+3.45 M**	4.60+6.70 H**	4.58+6.77 F**
Total Mg	0.103+0.005 C**	0.095+0.01 M*	0.120+0.006 H*	0.096-0.012 F*
Avail. P_2O_5	6.92-0.48 C*	6.24-0.69 M*	6.29-1.40 H*	5.96-1.25 F*
Exch. Mg	1.28+0.018 C*	1.21+0.048 M*	1.21-0.094 H*	1.22-0.093 F*

b. <u>KARAPPADAM</u> SOILS

	C	M	H	F
p^H	4.098-0.047** C	-	-	-
CEC	4.42+1.61** C	4.20+2.25** M	4.16+4.55** H	4.26+4.43** F
Total K_2O	0.086+0.030** C	0.073+0.043** M	0.072+0.088** H	0.075+0.085** F
Total Ca	0.076+0.022* C	0.084+0.028* M	0.085+0.057* H	0.085+0.056* F
Avail. K_2O	29.67+19.85** C	31.00+26.97** M	30.39+54.68** H	31.79+53.13** F
Exch. Mg	0.722+0.057** C	0.690+0.084** M	0.691+0.19** H	0.690+0.167** F

KAYAL SOILS

	C	M	H	F
Avail. N_2	211.51+25.68 C **	222.03+40.29 M **	230.94+82.46 H **	261.47+60.27 F **
Exch. Ca	9.00-0.535 C *	8.24-0.727 M *	8.38-1.624 H *	7.98-1.265 F *

d. LATERITIC ALLUVIAL SOILS

	C	M	H	F
p^H	6.00-0.161 C **	6.01-0.309 M **	5.96-0.587 H **	5.97-0.518 F **
CEC	4.04+1.32 C **	4.00+2.52 M **	4.41+4.70 H **	4.24+4.30 F **
Total N_2	0.048+0.078 C **	0.068+0.130 M **	0.080+0.258 H **	0.091+0.205 F **
Avaliable P_2O_5	-70.6+55.8 C **	-51.8+89.3 M **	-52.4+194.2 H **	-25.0+124.1 F **

xx - Significant at 1% level

x - Significant at 5% level

phosphorus exhibited a significant linear relationship with SOM and its fractions.

The signigicant linear relationship of different soil properties with SOM are presented in figures 6-17.

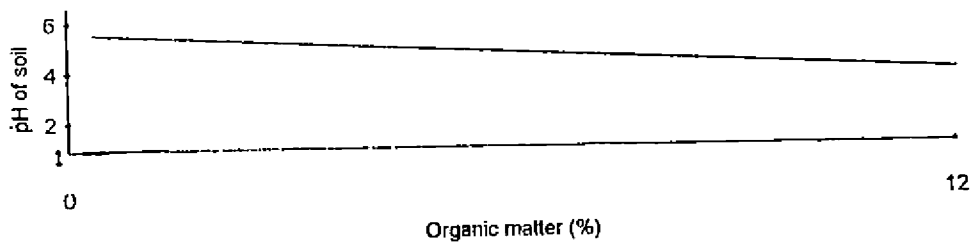


Fig.6(a) Relationship between pH and organic matter in Wetland soils

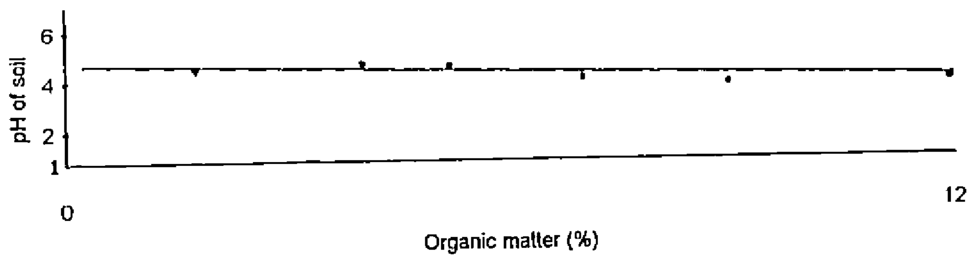


Fig.6(b) Relationship between pH and organic matter in Kari soils

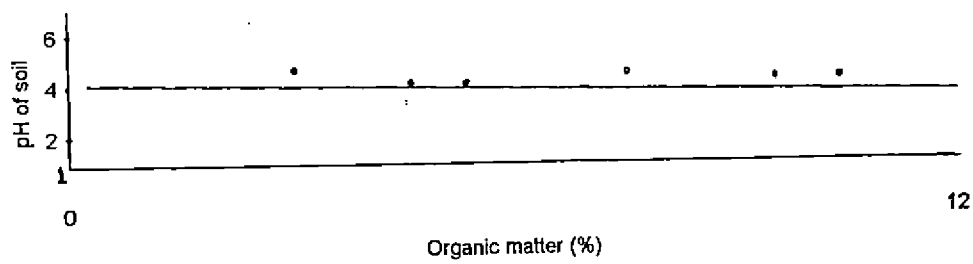


Fig.6(c) Relationship between pH and organic matter in Karappadam soils

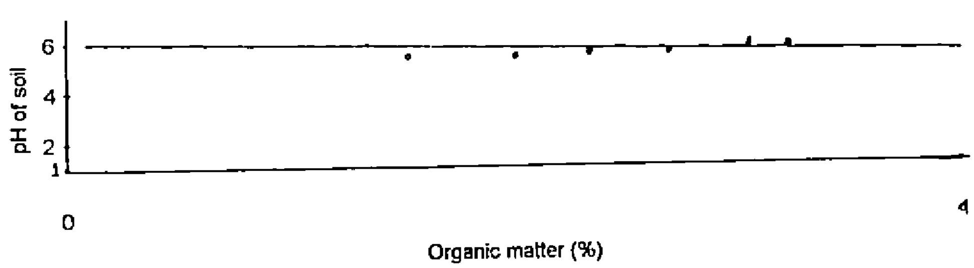


Fig.6(d) Relationship between pH and organic matter in Lateritic alluvial soils

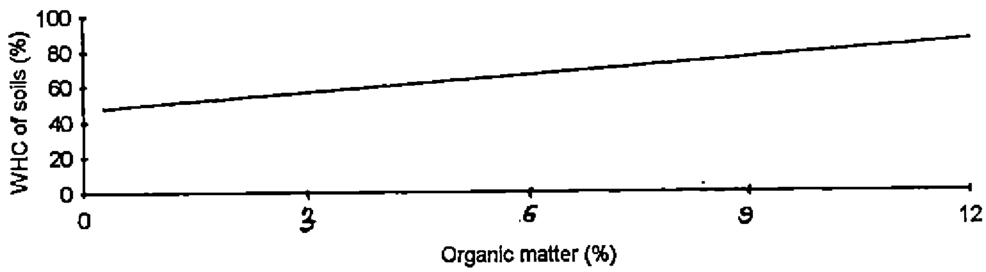


Fig.7(a) Relationship between organic matter and water holding capacity in Wetland soils

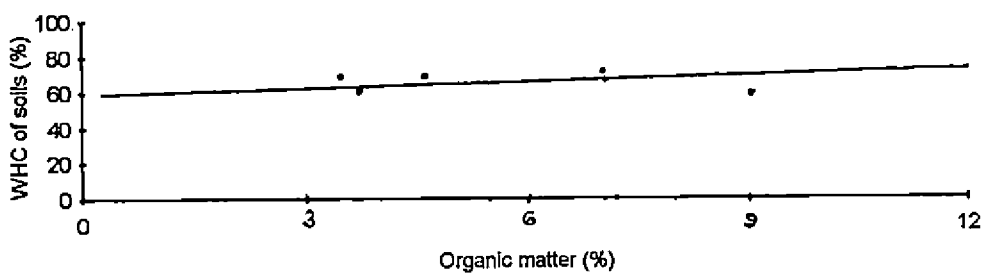


Fig.7(b) Relationship between organic matter and water holding capacity in Kari soils

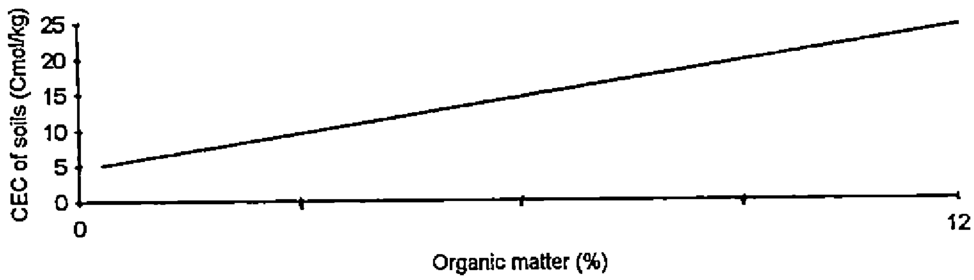


Fig.8(a) Relationship between organic matter and CEC in Wetland soils

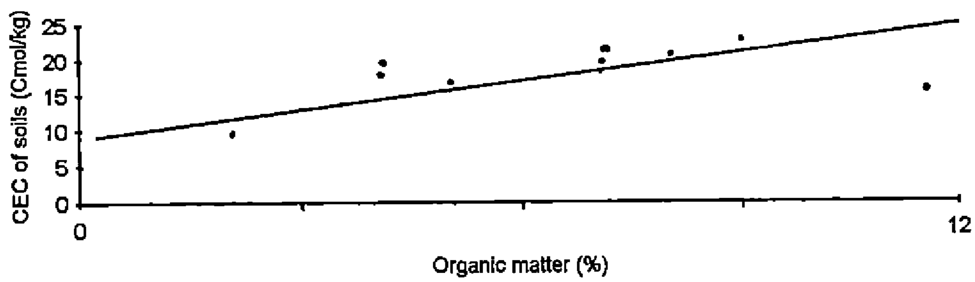


Fig.8(b) Relationship between organic matter and CEC in Kari soils

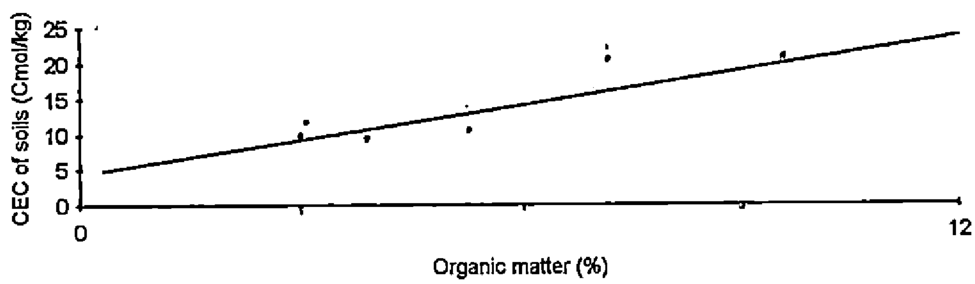


Fig.8(c) Relationship between organic matter and CEC in Karappadam soils

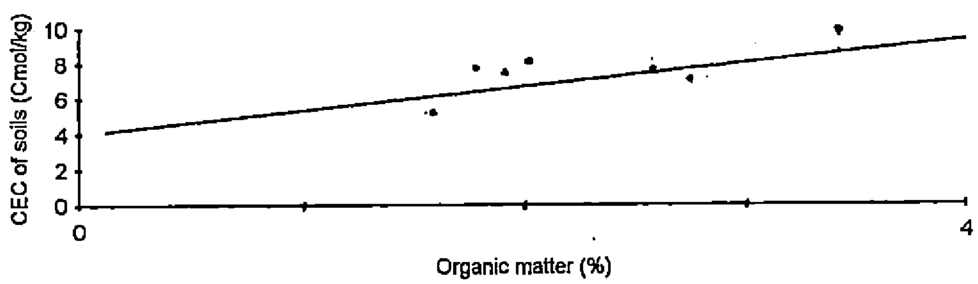


Fig.8(d) Relationship between organic matter and CEC in Lateritic alluvial soils

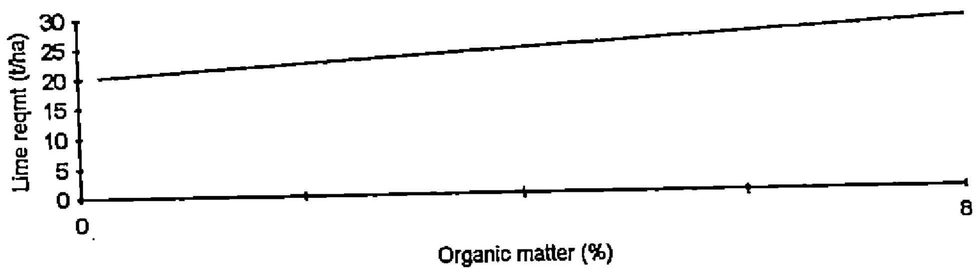


Fig.9 Relationship between organic matter and lime requirement in Wetland soils

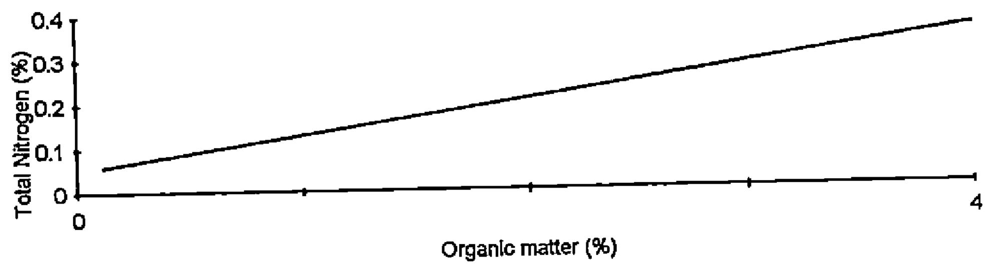


Fig.10(a) Relationship between organic matter and total nitrogen in Wetland soils

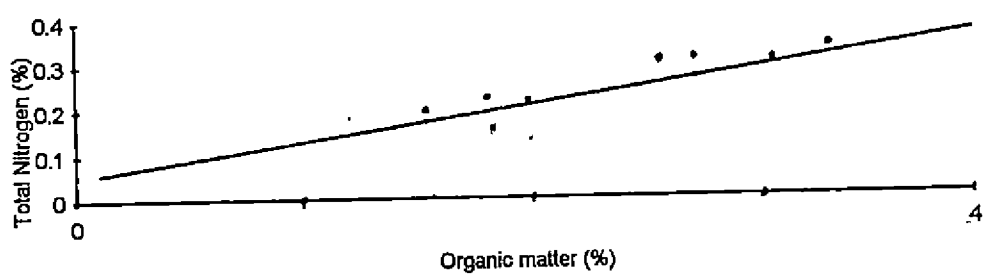


Fig.10(b) Relationship between organic matter and total nitrogen in Lateritic alluvial soils

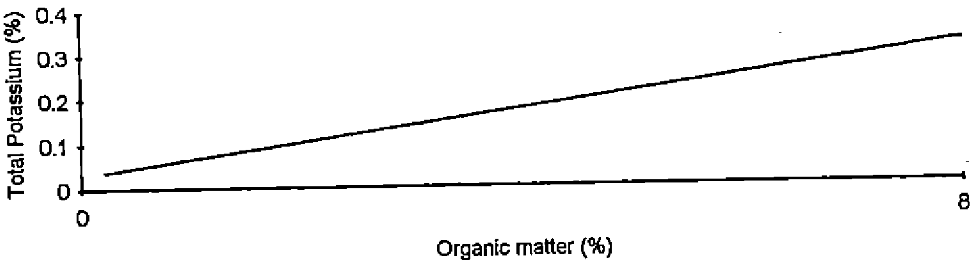


Fig.11(a) Relationship between organic matter and total potassium in Wetland soils

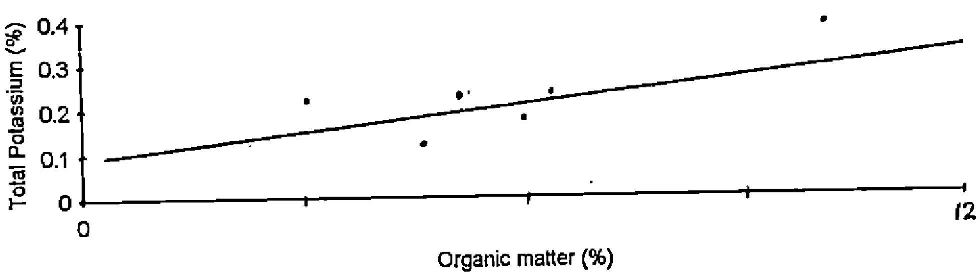


Fig.11(b) Relationship between organic matter and total potassium in Karappadam soils

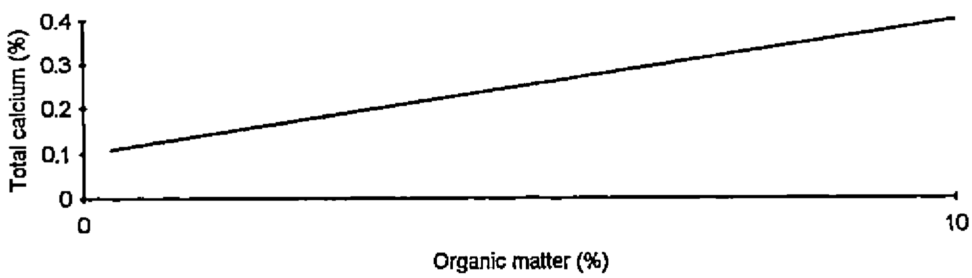


Fig.12(a) Relationship between organic matter and total calcium in Wetland soils

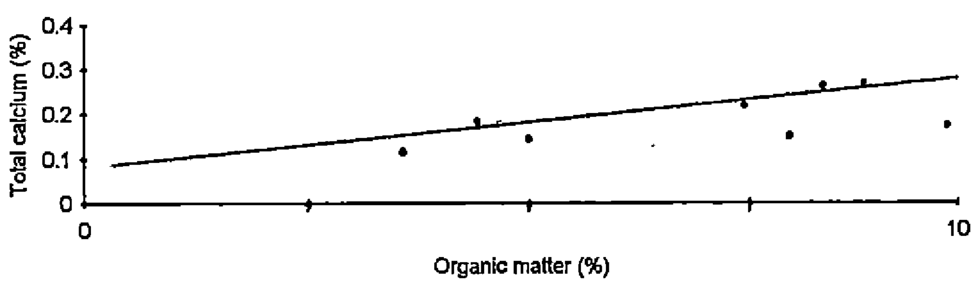


Fig.12(b) Relationship between organic matter and total calcium in Karappadam soils

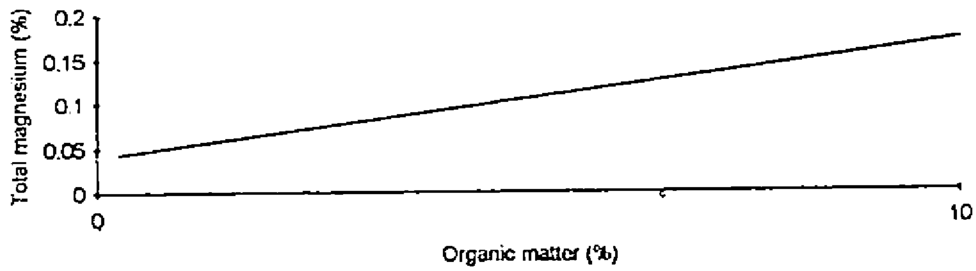


Fig.13(a) Relationship between organic matter and total magnesium in Wetland soils

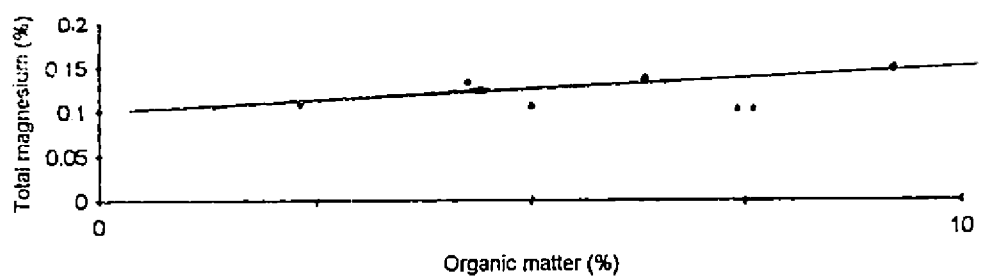


Fig.13(b) Relationship between organic matter and total magnesium in Kari soils

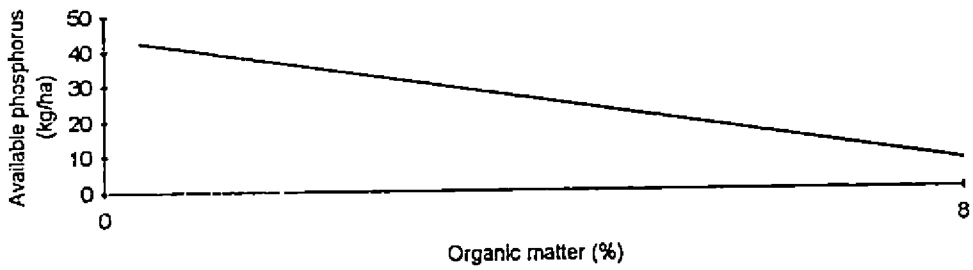


Fig. 14(a) Relationship between organic matter and available phosphorus in Wetland soils

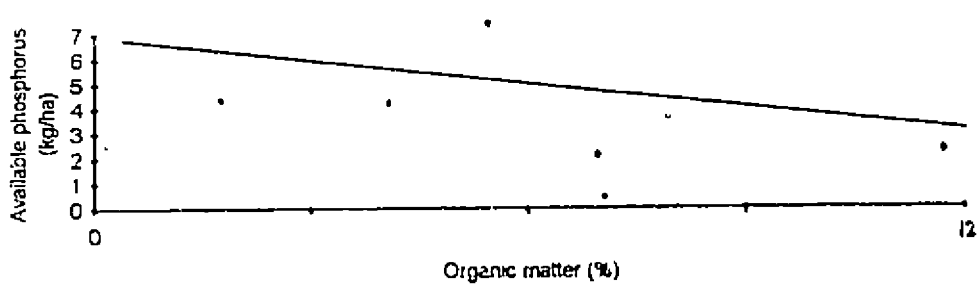


Fig. 14(b) Relationship between organic matter and available phosphorus in <u>Kari</u> soils

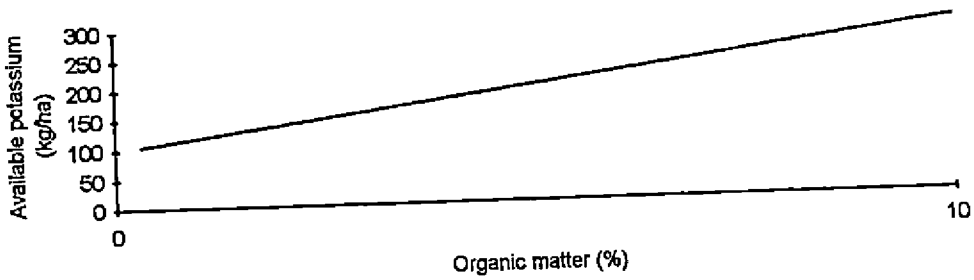


Fig.15(a) Relationship between organic matter and available potassium in Wetland soils

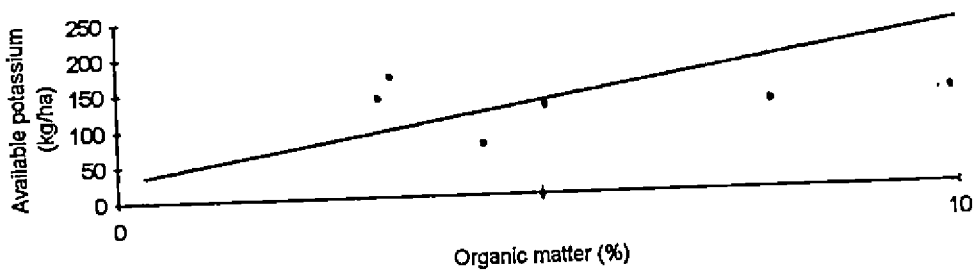


Fig.15(b) Relationship between organic matter and available potassium in Karappadam soils

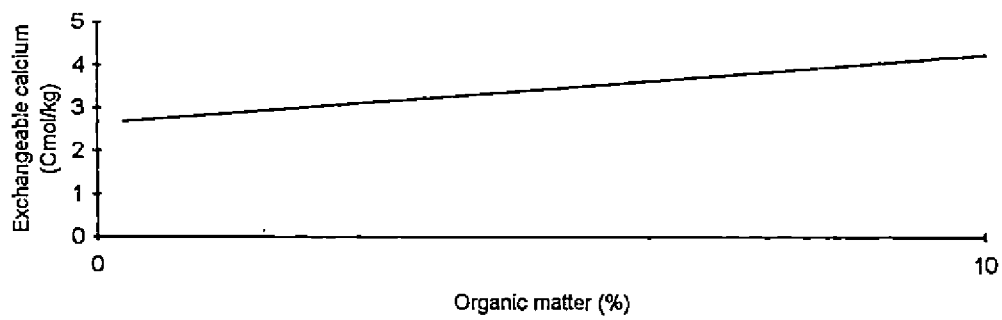


Fig.16(a) Relationship between organic matter and exchangeable calcium in Wetland soils

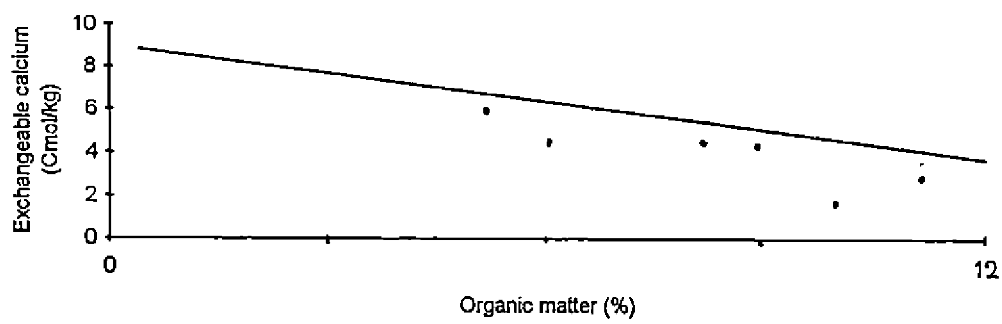


Fig.16(b) Relationship between organic matter and exchangeable calcium in Kayal soils

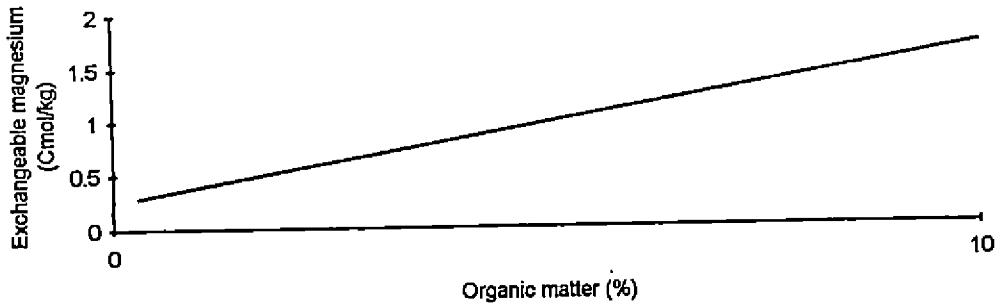


Fig.17(a) Relationship between organic matter and exchangeable magnesium in Wetland soils

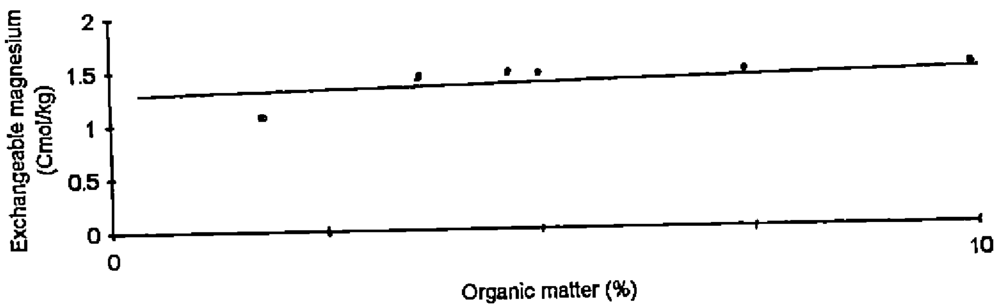


Fig.17(b) Relationship between organic matter and exchangeable magnesium in <u>Kari</u> soils

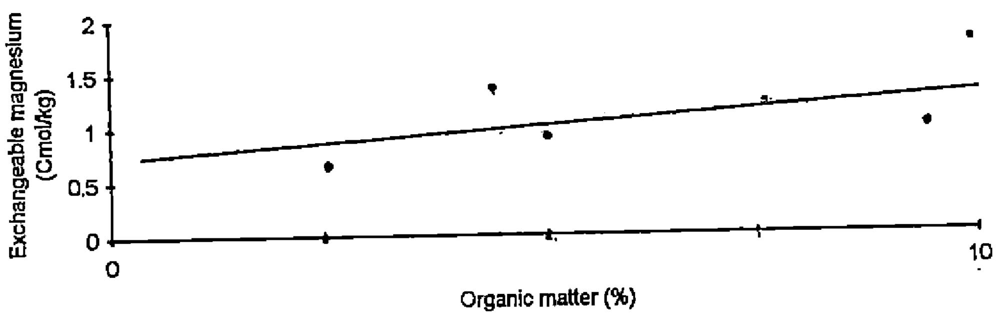


Fig.17(c) Relationship between organic matter and exchangeable magnesium in <u>Karappadam</u> soils

DISCUSSION

DISCUSSION

Kari, Karappadam and Kayal soils together known as 'Kuttanad' soils and the typical lateritic alluvial soils, which constitute the major wetland soils of Kerala were selected for the study on the interrelationship of humus with the fertility components. Kuttanad soils have the unique features of high acidity and high organic matter content whereas the lateritic alluvial soils are low in organic matter and are less acidic.

Kari soils are peat soils found in large isolated patches in Alleppey and Kottayam districts covering an area of about 20,000 ha. They exhibit characteristics of the forest areas which have been submerged under water for a very long period. The subsoil contains pyrite like minerals (Subramoney, 1959) which upon oxidation produces free sulphuric acid causing high acidity and toxic effect of iron and aluminium. Deep balck in colour, the soils are also characterised by heavy texture, poor aeration, high salt and organic carbon content. Large amounts of woody matter at various stages of decomposition also occur embedded in these soils. Karappadam soils occur along the inland waterways and rivers and are spread over a large part in upper Kuttanad covering an area of 41,000 ha, which lie at about 1-2m below the sea level. These soils are characterised by high acidity, high salt content and a fair amount of decomposing organic matter. _Kayal_ soils are found in the reclaimed lakebeds of Vembanad kayal and spread on Kottayam and Alleppey districts. They occupy an area of about 8,000ha. The land is situated 2-3m below the sea - level and are seriously affected by salinity. (Koshy _et al_., 1977, Abraham, 1984 and Chattopadhyay and Sidharthan, 1985).

Lateritic alluvial soils which account for more than 60% of the total rice soils in Kerala have originated from the washed out surface soils situated at a higher elevation. These soils are less acidic and clayey in texture and are devoid of any acid forming minerals (Unnikrishnan, 1993). Rice soils of Pattambi are typical examples of lateritic alluvial soils of Kerala.

According to Gopalaswamy (1961) and Iyer (1989), the _Kari_, _Karappadam_ and _Kayal_ soils are clayey in texture and the clay fraction in these soils are dominated by expanding type of 2:1 type clay minerals such as montmorillonite and illite. The lateritic alluvial soils are clayey loam in texture with more than half of the minerals predominated by kaolinite and other 1:1 nonexpanding minerals along with gibbsite (Unnikrishnan, 1993).

The surface samples of the different soil types described above were analysed for their organic matter content and properties such as pH, WHC, CEC, lime requirement, buffering capacity and total and available nutrients and the inter-relationships of these properties with SOM estimated. The important results from the study are disussed here.

5.1. VARIABILITY OF PROPERTIES WITHIN SOIL TYPES

From the results of the study, it is seen that apart from the significant differences between the four soil types, with regard to their basic soil characters including nutrient status, the individual soils representing each soil type showed considerable variability. Data presented in tables 1-4, indicate that most of the properties like WHC, CEC, organic matter, lime requirement and total and available nutrients showed considerable degree of variability within each soil group.

The organic matter content in Kuttanad soils ranged from 1.83 to 12.31% and it showed a coefficient of variation of 44.7% in _Kari_, 43.5% in _Karappadam_ and 21.2% in _Kayal_ soils. The organic matter content in lateritic alluvial soils is relatively low (2.24%) and the CV value is 26.5%. Earlier studies on the spatial variability of pedons of Alfisols and Mollisols of U.S.A (Wilding and Drees, 1978) also revealed SOM as one of the most variable properties, with CVs commonly exceeding 35%. Many of the CVs obtained in this study exceeded this value. In the present study, maximum degree of variability is shown in the available phosphorus content of all the soil types and the CV for the same is maximum in Kayal soils (160.8%), and minimum in Kari soils (85.1%). However, the pH and available nitrogen of all the four soil types showed the least degree of variability with CVs below 10% for pH and 10.9 to 19.7% for available nitrogen.

The spatial variability in soil properties within a soil type may be attributed to local differences in cultivation and management practices. The variability in lateritic alluvial soils may be due to the differences in organic matter treatments applied to soils of NPME plots.

Inspite of this high degree of variability within each soil type, many of the properties showed high correlations with SOM. The lack of significant correlation of some soil properties with organic matter in some soil types as observed in the present study may be due to this high degree of variability. However, when all the 60 samples of soil representing different soil types are taken together, most of the properties showed significant correlation with SOM and its fractions, inspite of the variability exhibited by individual soil types.

5.2. SOIL ORGANIC MATTER IN DIFFERENT SOIL TYPES

All soils contain cabon in the form of organic matter or humus, the two terms being used synonymously. But the absolute amount of organic matter vary from soil to soil (Kononova, 1961) depending upon the cultivation and management practices followed, along with the climatic conditions prevalent in each soil type (Dhandayuthapani et al., 1989).

Among the four soil types, Kayal soils have the highest content of organic mattter (8.03%), followed by Kari (7.58%) and Karappadam (6.81%) soils. The lateritic alluvial soils recorded the lowest value for organic matter which amounts to 2.24%.

The organic matter content in the Kari, Karappadam and Kayal soils were earlier reported to be as high as 43.1% (Subramoney, 1961) 13.9% (Money and Sukumaran, 1973) and 6.2% (Nair and Money, 1972) respectively. The drop in organic matter status observed in Kari and Karappadam soils may be due to changes in cultivation practices following the current system of double cropping as against the previous practice of single cropping. These soils, however contain a high content of SOM which accumulate and resist decomposition under conditions of inherent acidity and salinity resulting from the frequent inundation of sea water (Nair and Money, 1972).

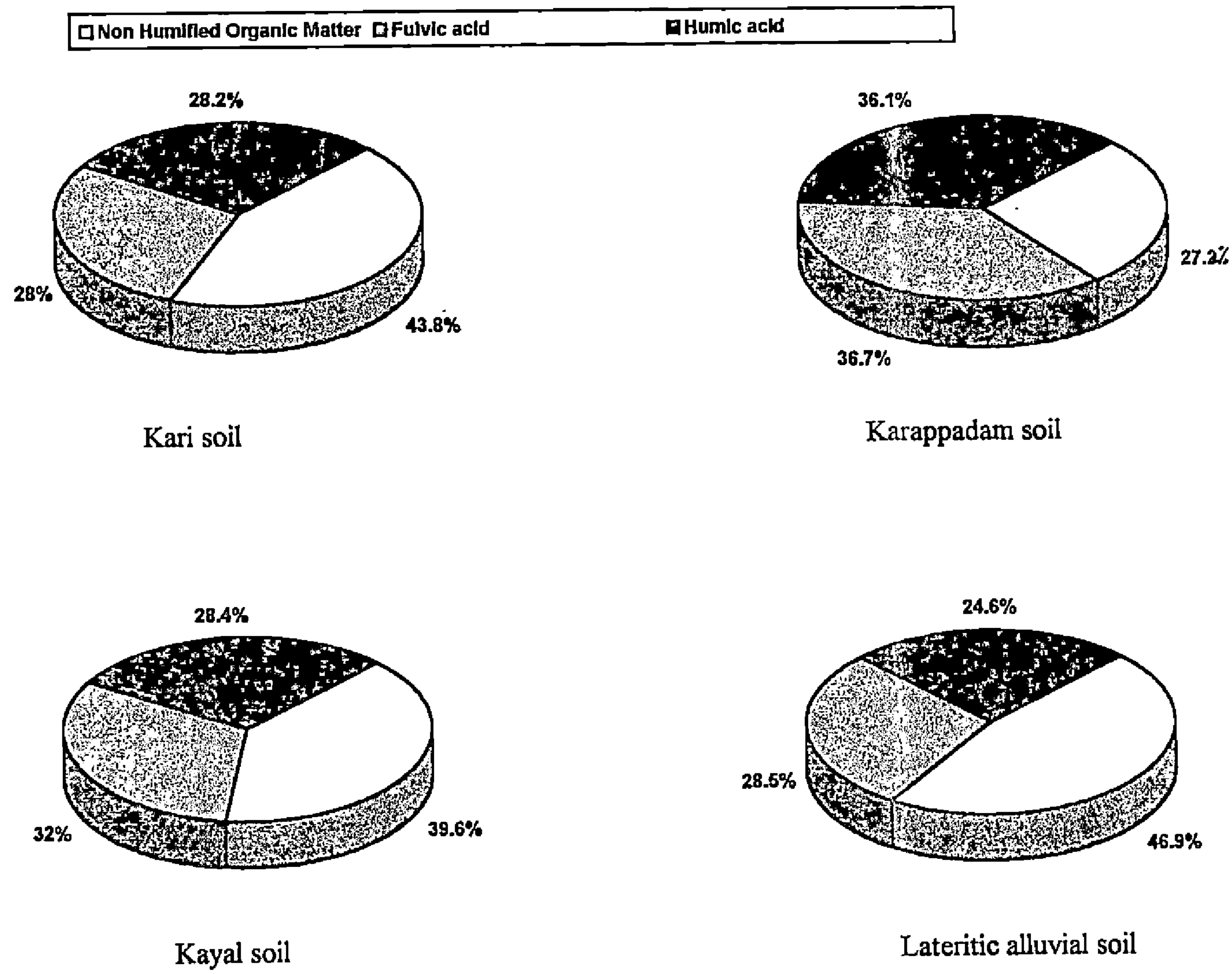


Fig.18 Fractions of Organic Matter in Soils

The lateritic alluvial soils which are several metres above sea level and are double cropped fields are not affected by acidity or salinity. In spite of the heavy application of organic manures in the NPME plots of R.A.R.S. Pattambi, the organic matter content in the samples (P_{10} - P_{15}) did not show much difference from that of the other samples representing the rice fields in Pattambi. These soils remain submerged during the first and second crop seasons and are dry in summer. The high temperature during summer helps in the decomposition of crop remains, which cause a stimulation for the breakdown of native SOM also (Alexander, 1977). These conditions support a dynamic microbial activity, which cause a continuous degradation of the SOM, resulting in a low, but stable level of organic matter in the lateritic alluvial soils.

5.3. FRACTIONS OF SOIL ORGANIC MATTER

SOM consists of two major fractions — non humified organic matter and humified organic matter. These two fractions in the four soil types were separated based on their solubility in 0.5N sodium hydroxide. The content of these two fractions showed much variation in the four soil types.

The non humified organic matter is represented by well known classes of compounds such as carbohydrates, fats, waxes and proteins, and originate from the decomposition of sugars, cellulose and hemicellulose in the plant remains by soil microflora. They synthesise polysaccharides and carbohydrates of their own and this also adds to the non humified organic matter which are the initial products of organic matter decomposition (Schnitzer and Khan, 1978).

The nonhumified organic matter content in Kari and Kayal soils, the average of which ranged from 3.17 to 3.32% are comparatively higher than that in Karappadam and lateritic alluvial soils having mean values in the range of 1.05 to 1.85%. Their contribution to the SOM (figure 18) is highest in lateritic alluvial soils (46.9%) followed by Kari (43.8%), Kayal (39.6%) and the least in Karappadam soils (27.2%). The high proportion of non humified organic matter in Kari soils may be due to the prevailing acidic condition which slows down the degradative and synthetic processes of soil organic matter, by hindering the microbial activity (Kononova,1961). In lateritic alluvial soils, the presence of a higher proportion of nonhumified organic matter may be attributed to the application of heavy doses of farmyard manure and green manures in some of the plots. (Gaunt *et al*., 1995)

The humified organic matter which represents the most active fraction of humus, consists of a series of highly acidic, yellow to black coloured , high molecular weight polyelectrolytes such as humic acid and fulvic acid. It is the final stable form of humus resulting from the progressive degradation of added organic matter and represents the organic colloids which contribute to many soil properties including nutrient availability. Its content in soil depends on the climate, physicochemical properties and number, type and activity of soil microflora (Schnitzer and Khan, 1978).

Among the four soil types, Kuttanad soils contained a significantly higher amount of humified organic matter (means ranging from 4.26 - 4.96%) than lateritic alluvial soils (1.19%) as seen from figure 19. The humified fraction occupies more than 70% of SOM in Karappadam, more than 60% in Kayal and above 50% in Kari and lateritic alluvial soils. The comparatively higher proportion of humified organic matter in the Karappadam and Kayal soils may be due to their greater retention by adsorption on to the colloidal mineral matter. They may be held on the crystal lattices by way of Vander Waal's forces and hydrogen bonding, or by forming complex alumino and ferro humic gels which are firmly fixed in soils or by forming alkali and alkaline earth metal humates and fulvates as proposed by Kononova (1961). These forms

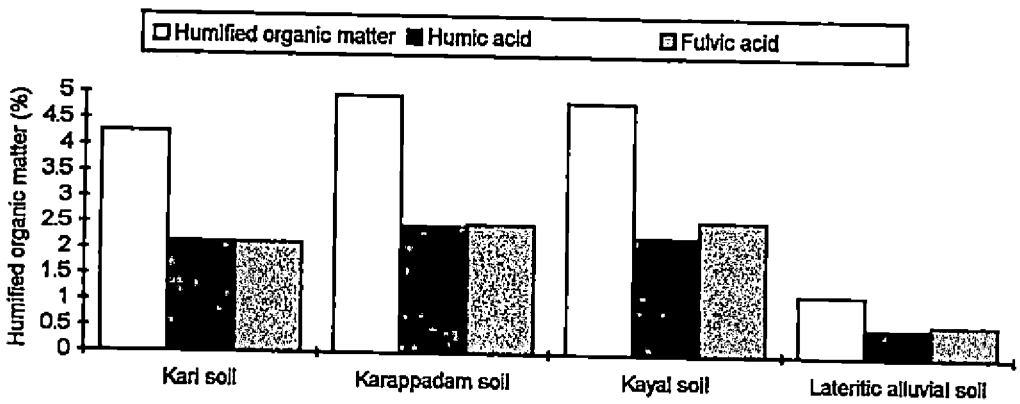


Fig. 19 Fractions of Humified Organic Matter in Soils

reduce their availability for microbial attack and results in prolonged retention (Kononova, 1961). Another important factor determining the stability of organic matter, as proposed by Wada (1980) and Virakornphanich et al. (1988), is the association with active aluminium in very acid soils. In lateritic alluvial soils, the absence of such humus-clay complexes may result in a faster degradation and lower retention of SOM. It may be noted that these soils are predominantly kaolinitic and chances for humus-clay complex formation are less as proposed by Kononova (1961).

The HA and FA components of humified organic matter also showed a similar trend in these soils. HA/FA ratio, which is an index of the degree of degradation of humified organic matter showed wide variation. Only in Kari soils, the ratio exceeded unity, which indicates the predominance of HA over FA fraction. This may be attributed to the acidic condition in these soils which slows down the microbial degradation of HA to FA (Kinzerskaya, 1935). This results in a greater accumulation of HA in soil (Schnitzer and Khan, 1978). In all the other soils, the HA/FA ratio was less than one, indicating a higher degree of degradation of humified organic matter resulting in a higher content of FA.

5.4. DEPENDENCE OF SOIL PROPERTIES ON ORGANIC MATTER

Destruction of organic matter has resulted in a considerable reduction in pH, WHC, CEC, lime requirement, buffering capacity and nutrient status of soils. The difference represents the extent of association of each character with the organic matter present in each soil type.

5.4.1. SOIL REACTION (pH)

The Kuttanad soils are highly acidic with a mean pH of 4.2 for Kari and Kayal soils and 4.4 for Karappadam soils, Whereas lateritic alluvial soils are less acidic with a mean pH of 5.6. The low pH of Kuttanad soils may be attributed to several factors. Toxic concentrations of iron and aluminium (Pillai and Subramanyan, 1931, and Money and Sukumaran,1973) and sulphuric acid produced from the organic forms of sulphur and pyrite like minerals present in the subsoil (Subramoney, 1959) are responsible for higher acidity. The predominance of 2:1type minerals in these soils also contribute to low pH as proposed by Pillai and Subramoney (1967). Besides, the organic acids produced during the decomposition of soil organic matter also contribute to soil acidity (Hedin et al., 1990 and Biswas and Mukherjee, 1990).

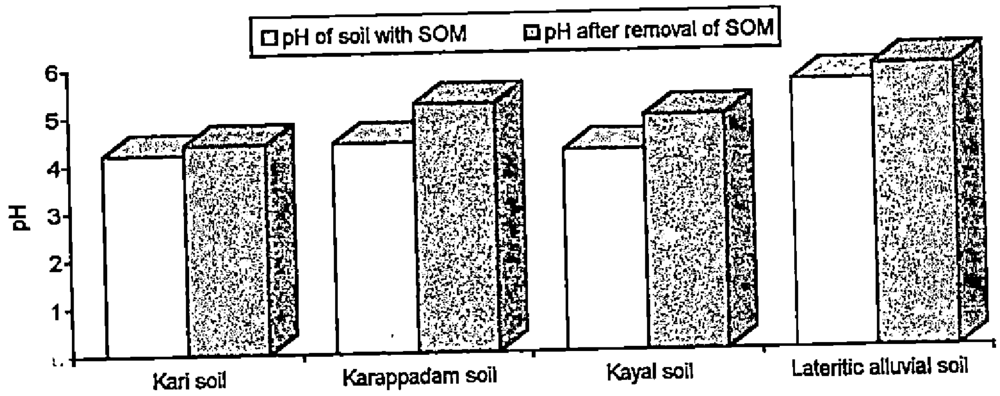


Fig.20 Contribution of Organic Matter to pH of Soils

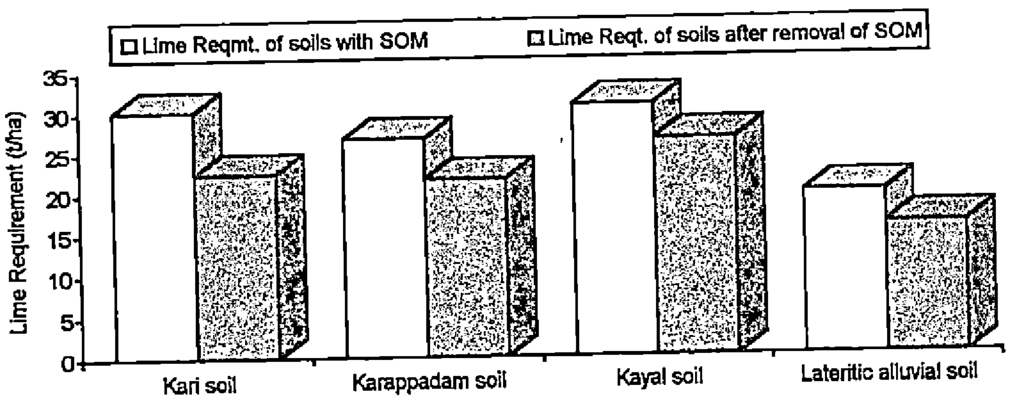


Fig.21 Contribution of Organic Matter to Lime Requirement of Soils

Lateritic alluvial soils are devoid of any acid forming minerals as the Kuttanad soils. As the organic matter content is low, its contribution to the developement of acidity is also negligible. The contribution of organic matter to pH was maximum in Karappadam soils (18.4%) followed by Kayal (17.2%) and Kari (7.1%) soils and it was least (4.2%) in lateritic alluvial soils. Though the content of SOM is maximum in Kayal soils , its contribution to pH is maximum in Karappadam soils (figure 20). This may be due to the higher content of humified organic matter (table 10) present in them. The results show that it *is* not the actual content of total organic matter, but its humified part is controlling the pH in soils as reported by Savich and Diallo (1989). The low pH value of the Kari soil helps to arrest the deprotonation of carboxyl, phenolic and other functionaal groups in humus resulting in only a lower contribution to soil acidity.

In all these soils, SOM and its fractions showed negative correlation with pH which was significant in Kari, Karappadam and lateritic alluvial soils. They also showed linear relationship with pH as seen from figures 6a-6d. This may be due to the presence of carboxylic, phenolic and alcoholic hydroxyl groups in the humified organic matter (Tan, 1982). These groups when dissociates in soil, release H^+ ions and contribute to acidity

(Greenland and Hayes, 1978). The high correlation of pH with humified organic matter can be attributed to the humic and fulvic acid components of humus, which are reported to contribute 560-890 and 640-1420 me / 100g of H^+ ions respectively (Stevenson, 1986).

5.4.2. WATER HOLDING CAPACITY

Retention of water by the soil as a result of the presence of retaining forces associated with the mineral and organic components of the soil matrix is reflected in the WHC of soils. Soil water is held in the interstices or pores or capillaries between solid particles and by adsorption on the solid surfaces of clay and organic matter particles. WHC is a function of the mineralogical make up of soil clays, poresize distribution, as well as the nature and content of SOM.

Volume for volume,orgnic matter can hold over twice as much water as do soils at saturation. (Greenland and Hayes,1978). This greater influence of organic matter in water retention is through soil structural changes which results in changes in poresize both within and between aggregates (Larson and Clapp, 1984). This increases the capillary retention of water. Besides, carboxyl groups present both as free acids and ionic form, phenolic and alcoholic hydroxyl groups, amides, amines,

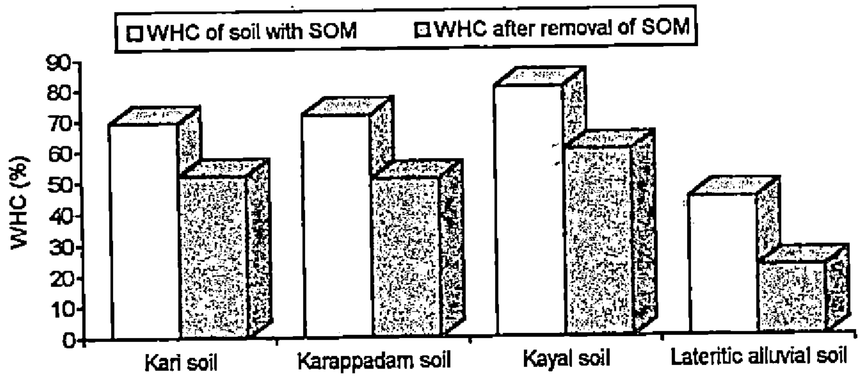


Fig.22 Contribution of Organic Matter to WHC of Soils

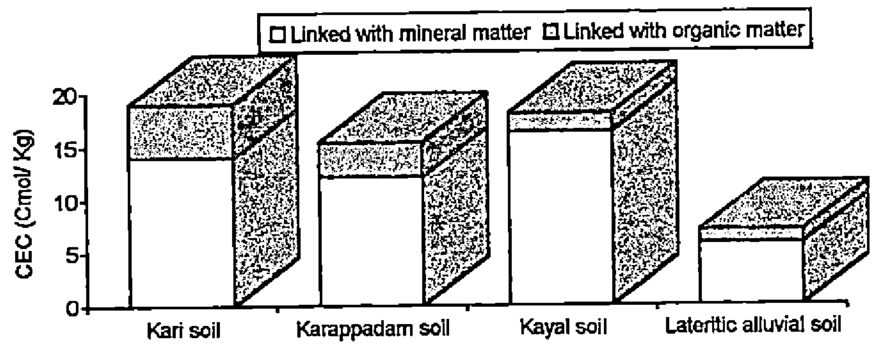


Fig.23 Contribution of Organic Matter to CEC

Gbadegesin (1989) has identified SOM as the most important factor contributing to more than 42% of the WHC of soils.

In all soil types, WHC is positively correlated with SOM and its fractions (figure 7). This may be attributed to an incresed interaggregate and intra-aggregate porosity and incresed adsorptive capacity of soil as suggested by Snyder _et al_. (1993) and Kahle _et al_. (1992).

5.4.3. **CATION EXCHANGE CAPACITY**

CEC is the sum total of all the exchangeable cations that a soil can adsorb. The ability to adsorb and retain exchangeable cations is attributed to the negative charges on the surface of organic and mineral colloidal fractions in soil. It depends on the nature and content of clay and organic matter and varies with changes in pH value. Generally higher CEC values are associated with a rise in pH. The negative charges on mineral colloids may be permanent, which arise from the isomorphous substitution of cations in the lattice of clay minerals or pH dependent. The pH dependent charges arise by deprotonation of Al-OH or Si-OH groups on the broken edges of clay minerals. The charges on organic colloids are pH dependent and arise from deprotonation of functional groups such as carboxylic, phenolic, enolic and imide groups in the aromatic cyclic compounds which predominate the humified portion of SOM. As pH increases, the contribution to CEC by humus also increases.

Kari, Karappadam and Kayal soils have high CEC values of 19.0, 15.4 and 18.1 Cmol kg^{-1} respectively and the lateritic alluvial soils of Pattambi are with a comparatively lower CEC values of 7.0 Cmol kg^{-1}. The high values for CEC recorded by Kuttanad soils may be attributed to the combined effect of organic and inorganic colloids. The predominance of 2:1 type minerals in these soils has contributed to the high CEC as proposed by Venugopal and Koshy (1978). The possible role of SOM in increasing the CEC is evident from the high status of SOM in these soils.

Association of cation exchange properties of soils with SOM is clearly brought out in the lowering of CEC after destruction of organic matter in them. The organic matter contributed to 27.2% of CEC in Kari, 19.6% in Karappadam, 9.7% in Kayal and 16.8% in lateritic alluvial soils (figure 23). The fractionation of SOM has further showed that more than 50% of the SOM in all the soils is humified and this fraction is reported to result in the formation of humic and fulvic acids which possess higher CEC (Kononova, 1961).

Though the content of organic matter is the highest in Kayal soils, its contribution to CEC is the lowest. This may be due to the possible formation of clay-humus-complexes which is predominant in clayey soils, dominated by montmorillonite minerals (Russel, 1961). He has also stated that in the tropics, montmorillonite clays, under conditions of poor drainage form clay-humus-complexes in soils rich in organic matter. The CEC of clay-humus-complex is reported by Russell (1961) to be less than that of clay and humus if measured separately.

In lateritic alluvial soils, though the content of organic matter is low, its contribution to CEC is higher and amounts to 16.8%. This may be due to the relatively high pH of these soils. Increse in pH is known to increase the pH dependent charges both in the clay and organic colloids, resulting in a higher CEC (Bear, 1964). The contribution to CEC by mineral matter in the lateritic alluvial soils is low, as more than 50% of the clay fraction is dominated by low activity kaolinitic minerals. It may be noted here that lateritic alluvial soils had a low CEC value of only 7.0 Cmol kg $^{-1}$.

Among the four soil types, except Kayal soils, CEC of all soil types, is significantly and positively correlated with SOM as well as with its fractions. The relationship between CEC and SOM and its fractions is linear (figure 8) supporting the view that CEC is highly dependent on SOM. Similar results were also obtained by Venugopal and Koshy (1976) in Kerala soils and Kaliz and Stone (1980) and Drake and Motto (1982) in soils of other countries.

In Kayal soils, however, no such relationship is obtained and contribution to CEC by SOM was also minimum. This may be, as explained before, attributed to the formation of clay-humus-complexes, under the poorly drained soil conditions. As stated by Larson and Clapp (1984), these complexes exist in soils as small aggregates and the SOM as well as clay in this, is not easily accessible for exchange reactions.

5.4.4. BUFFERING CAPACITY AND LIME REQUIREMENT

Buffering capacity expresses the resistance offered by a system to change in pH due to the addition of any acidic or basic ammendments. In soils, most of this property is due to the charges on the colloidal particles which are located in the humus clay surfaces. These negative charges attract and hold hydrogen, aluminimum and other cations. The total content of clay and organic matter in a soil and the nature of clay minerals determine the extent to which soils are buffered. The soils with high content of clay and SOM are highly buffered and require large amounts of lime to neutralise their acidity (Biswas and Mukherjee, 1990).

The results from the present study reveal that Kari, Karappadam and Kayal soils are highly buffered, whereas lateritic alluvial soils are poorly buffered (figures 1-5). The lime requirement for Kuttanad soils is also significantly higher than that of lateritic alluvial soils. This highly buffered nature of Kuttanad soils may be due to high content of organic matter and high exchangeable aluminium present in them, as reported by Karthikakutty et al. (1979) and Abraham (1984). The predominance of 2:1 type clay minerals also make them strongly buffered than those dominated by 1:1 type clay which are less buffered (Tisdale et al., 1990). Poorly buffered nature of lateritic alluvial soils may be due to low organic matter content, lack of acid forming materials like exchangeable aluminium and a predominance of 1:1 type minerals in clay fraction. Such conditions as cited by Aitken et al. (1990) are known to reduce the buffering capacity of soils. This condition resulting in a relatively high soil pH value, is reflected in the lower lime requirement in the lateritic alluvial soils.

Destruction of SOM, in these soils has resulted in a considerable reduction in lime requirement values, which amounts to 25.5% in Kari, 18.9% in Karappadam, 13.9% in Kayal and 20.8% in lateritic alluvial soils (figure 21). The higher requirement of lime to neutralize the potential acidity in humus molecules is reflected in the higher dependence of this character on SOM. These results elucidate the role of humus in raising the buffering capacity of soils and lime requirement values as reported by earlier workers in this field (Keeney and Corey, 1963 and Ross et al., 1964). In Kuttanad soils except Kayal soils, the high requirement of lime to neutralise the acidity may be attributed to the high humus content in them. In Kayal soils, though the content of humus is high (8.03%), its contribution to lime requirement is relatively low (13.9%). This may be due to the possible existence of clay-humus-complexes which resulted in the lowering of pH dependent charges in them. The influence of clay-humus-complexes in reducing the WHC and CEC of the Kayal soil, has also been discussed before.

In lateritic alluvial soils, with relatively low SOM, its contribution to lime requirement is high, probably due to the release of pH dependent acidity at the high soil pH. Such instances are reported by Magdoff and Bartlett (1985) where within a low buffering zone, organic matter and lime requirement showed a linear relationship. The linear relationship is seen in figure 9.

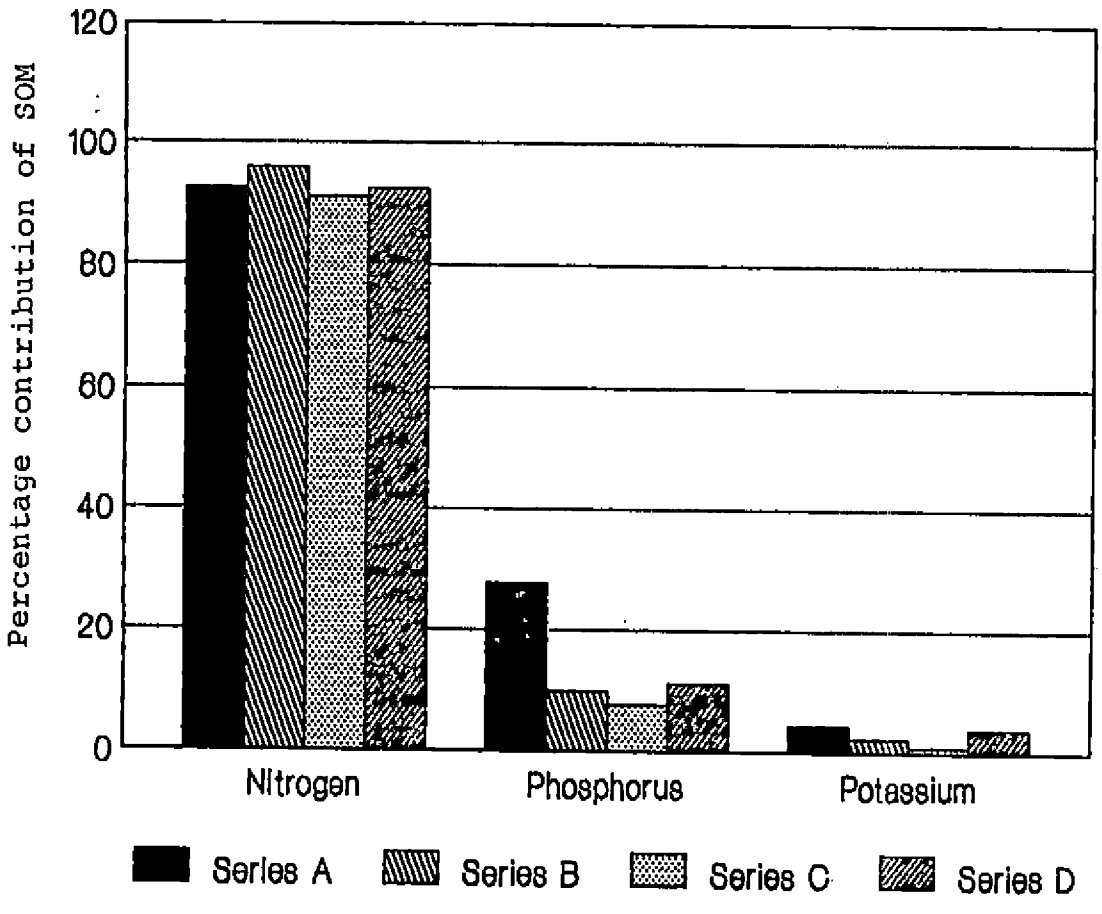
As proposed by Magdoff and Bartlett (1985) the role of humus in buffering of soils at low pH may be by two methods. It can be a source (sink) for H^+ in the strongly acidic carboxyl groups or it may allow more of the adsorbed aluminium to come into solution during acidification.

In the wetland soils under study, the contribution of organic matter to buffering capacity is relatively low as compared to that in certain acid sulphate soils where, SOM clay content and exchange acidity together accounted for 85% of the variance in buffering capcity, with SOM being the most important factor, as reported by Aitken et al. (1990).

5.5. NUTRIENTS AND ORGANIC MATTER

SOM acts as a storehouse of plant nutrients and it exhibits direct and indirect effects in nutrient availability. The macronutrients like nitrogen, phosphorus, potassim calcium and magnesium are associated with the SOM, either as its structural component, or held on its surface. It is generally agreed that humus is a positive asset for crop production and that the practices which deplete the humus reserves in soil also deplete the nutrient status of soil. The influence of humus in the wetland soil types of Kerala, on the various plant nutrients (figure 24) are discussed below.

Fig.24. Contribution of organic matter to major nutrients in soils



Series A - Kari soil
Series B - Karappadam soil
Series C - Kayal soil
Series D - Lateritic alluvial soil

5.5.1. NITROGEN

The major plant nutrient, nitrogen, occur in soil mostly in organic form. About 93-97% of the total nitrogen in soil is reported to occur in organic combination and the remainder as nonexchangeable (fixed) ammonium or inorganic form (Stevenson,1986).

The total nitrogen amounts to 0.28% in Kari, 0.32% in Karappadam and Kayal and 0.22% in lateritic alluvial soils. Relatively higher content of nitrogen in Kuttanad soils may be due to high content of SOM and predominance of expanding type 2:1 minerals, which might hold in between their lattices, ammonium ions in a fixed position (Bear, 1964). The low content of nitrogen in Pattambi soils may be attributed to a low content of SOM as well as to the predominance of non-expanding 1:1 type minerals, which cannot fix ammonium ions.

Results from the determination of soil nitrogen after destruction of organic matter, indicated that SOM contributed to more than 90% of total nitrogen in all these soils. The rest of the soil nitrogen may be associated with mineral matter (figure 24a). Nitrogen in SOM is known to exist in two forms - mainly as a structural component of humified organic matter and as NH_3 incorporated into a wide variety of compounds in SOM (Stevenson, 1986).

Significant amount of soil nitrogen (>50%) occur as structural component of humic substances. It may be as amino acids attached to aromatic rings, bridge constituents linking quinone groups, part of a heterocyclic ring, open chain (-NH-,=N-) groups and as peptides and proteins held through hydrogen bonding, as reported by Stevenson and He (1985).

Total nitrogen in all these four soils are positively correlated with SOM as well as with its fractions. Recke et al. (1990) have shown that inspite of the presence of a high amount of organic nitrogen, only the hydrolyzable aminoacid component of organic nitrogen showed a close correlation with humus. The hydrolyzable aminoacid which forms a meagre portion of organic nitrogen consists of ammoniacal, aminoacid and hexosamine forms, which decrease with the progress of humification (Kumada, 1956). This may be the reason why the relationship between nitrogen and humus, though positive is not significant in Kuttanad soils, where a major portion of organic nitrogen might occur in forms other than hydrolyzable aminoacid. In lateritic alluvial soils, with more than 50% of clay dominated by Kaolinite, the majority of soil nitrogen may reside in SOM. The significant linear relationship (figures 10a and 10b) with SOM may be due to a high content of hydrolyzable aminoacids.

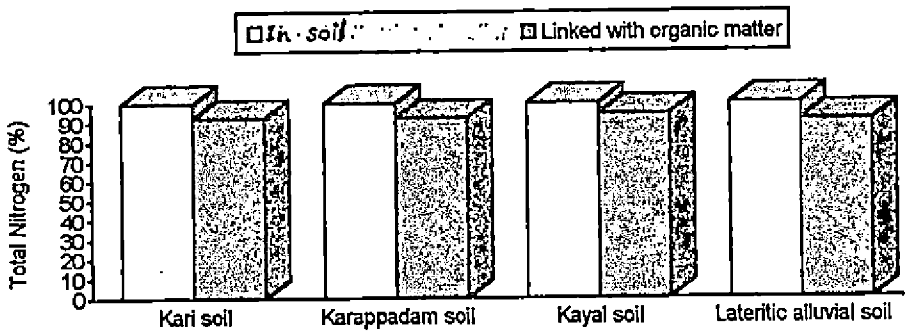


Fig.24(a) Contribution of Organic Matter to Total Nitrogen

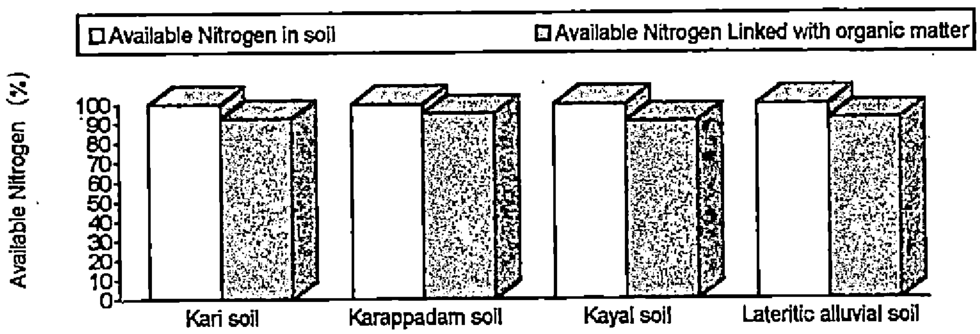


Fig.24(b) Contribution of Organic Matter to Available Nitrogen

The available nitrogen in soil, which accounts for about 2-5% of the total nitrogen (Stevenson, 1986) is also influenced by SOM. Organic matter contributed to more than 90% of the available nitrogen in all the soils (figure 24b). The available nitrogen in these soils showed a positive correlation with SOM and its fractions. The relationship between available nitrogen and SOM follows the same pattern as that between total nitrogen and SOM as discussed above.

5.5.2. **PHOSPHORUS**

Total phosphorus in soils occur in inorganic and organic forms. Bulk of the inorganic forms consists of orthophosphates of iron and aluminium in acid soils and that of calcium in alkaline soils, which are not readily available to plants. Plant available forms of phosphorus in soil occupies the labile pool which consists of mineralizable organic phosphorus and phosphates weakly adsorbed on clay colloids. The amount of phosphorus linked to SOM is reported (Dalal,1979) to range from 20-80%, although the exact amount depends upon the nature of soil and its composition.

<u>Kari</u>, <u>Karappadam</u>, <u>Kayal</u> and lateritic alluvial soils registered a total phosphorus content of 0.044, 0.077, 0.143 and 0.117% respectively. The SOM contributed to 35.2% in <u>Kari</u>, 9.8%

in *Karappadam*, 5.6% in *Kayal* and 10.4% in lateritic alluvial soils of the total phosporus. The contribution of SOM to phosphorus is highest in *Kari* soil, which may be due to the high content of organic matter in it. In the other three soil types, most of the soil phosphorus appears to be bound in mineral matter (figure 25a). A low association of phosphorus with SOM has been reported by Barrow (1961) and Kaila (1963) and it may be due to the fact that unlike nitrogen, phosphorus is not a structural component of humic substances like HA and FA (Stevenson, 1986). In Kuttanad soils, generally most of the phosphorus occur in fixed forms as iron and aluminium phosphates (Koshy and Britomuthunayagam, 1961 and Madhusoodhanan and Padmaja, 1983).

The existence of phosphorus by anion exchange in the kaolinitic clays of the lateritic alluvial soil may be one reason for the lower association of phosphorus with SOM.

However, the total phosphorus is positively correlated to organic matter and to humic acid and fulvic acid in all these soils. This may be due to the presence of humus-P-complexes which increases with increase in humus content (Borie and Zunino, 1983).

Available phosphorus, which is a fraction of toal phosphorus in exchangeable form, exist in both organic and inorganic forms.

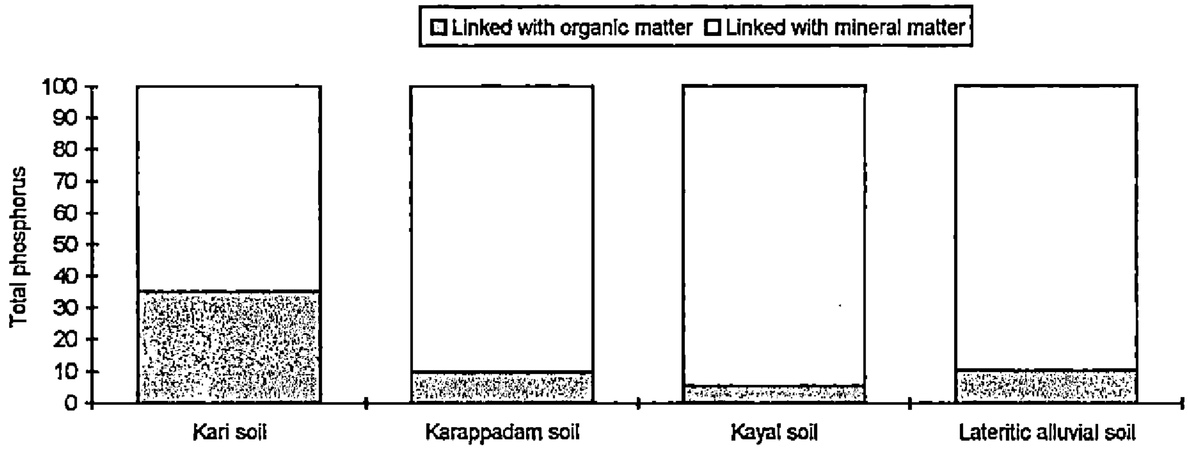


Fig.25(a) Contribution of Organic Matter to Total Phosphorus

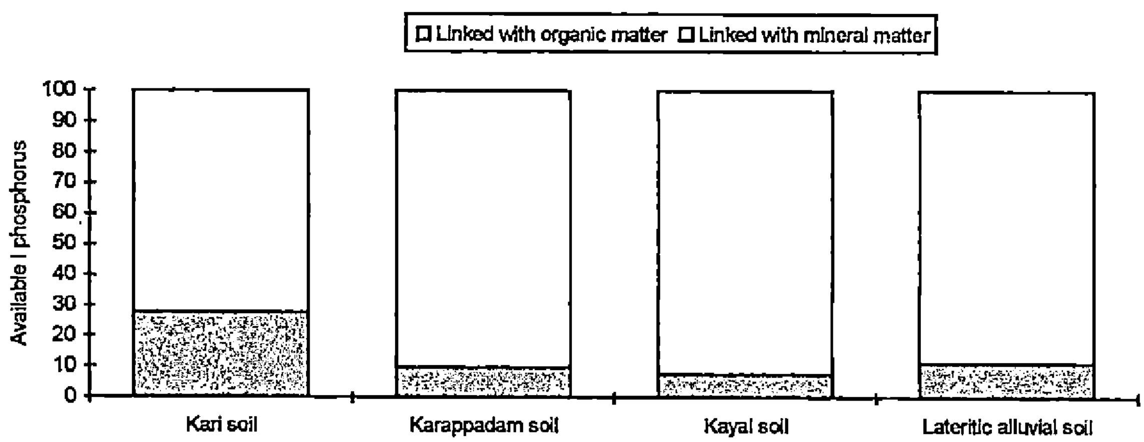
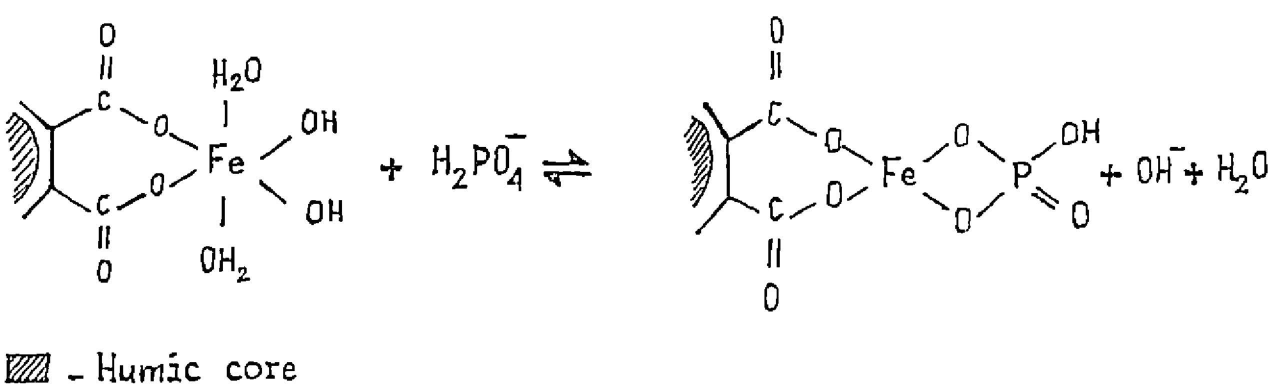


Fig.25(b) Contribution of Organic Matter to Available Phosphorus

Available phosphous in Kuttanad soils showed a high degree of variability within all the three soil types. It ranged from traces to 31.36 kg ha^{-1} and in lateritic alluvial soils, the range is 8.96 to 190.40 kg ha^{-1}. Inspite of the high content of organic matter, the available phosphorus content in Kuttanad soils is comparatively low (fugure 25b). Kuttanad soils in general showed a negative correlation between SOM and available phosphorus (figure 14). This may be due to the possible existence of humus-Al-P and humus-Fe-P complexes, where the phosphates can be bound to humic substances through ligand exchange via iron and aluminium bridges as shown by White and Thomas (1981), Borie and Zunino (1983) and Gerke and Hermann (1992). This complex formation results in lower available phosphorus. Under such conditions even though the organic phosphorus content may be high, it may not be mineralisable owing to its strong linkage to humic substances, the formation of which is schematically represented by Gerke and Hermann (1992) as follows:



Inspite of the low content of organic matter, however, in the lateritic alluvial soils, the available phosphorus status is relatively high. This may be due to the absence of humus Al-P/humus-Fe-P complexes, due to a low content of soluble iron and aluminium existing at a near neutral pH.

The SOM contributed to 27.7% of available phosphorus in Kari, 9.7% in Karappadam, 7.6% in Kayal and 11.1% in lateritic alluvial soils. The comparatively higher contribution of organic matter to available phosphorus in Kari soils may be due to the existence of phosphate adsorbed on SOM in exchangeable form (Bear, 1964).

The relationship between available phosphorus and SOM is positive only in lateritic alluvial soils. This may be due to the absence of humus-Al-P/humus-Fe-P complexes in these soils, as explained earlier which do not restrict the release of phosphorus from SOM. A greater proportion of SOM in lateritic alluvial soils is nonhumified, which are still in the process of decay. The decay processes produce organic acids which can chelate any soluble iron and aluminium and prevent them from precipitating phosphorus into insoluble forms. Also the humic anions may compete with phosphate ions for adsorbing surfaces resulting in the release of more phosphorus in available forms. These may be the reasons for positive correlation between available phosphorus and SOM in lateritic alluvial soils.

5.5.3. POTASSIUM

Potassium in soil is present either as fixed or unavailable form constituting 98% of the total potassium supply and the remaining as exchangeable form. Potassium associated with organic matter in soil is grouped under the category of exchangeable form which comes to about 0.1 - 2% of the total potassium. These forms are held by electrostatic forces on the surface of negatively charged clay and organic colloids.

The Kuttanad soils contain higher amounts of total potassium, the average values ranging from 0.22-0.42%. 3.5% of this, is found to be associated with SOM as seen from the results of analysis after destruction of organic matter. The high total potassium content may be due to the predominance of 2:1 type clay minerals which hold considerable amount of Potassium in exchangeable and fixed forms. The presence of primary minerals like feldspars and micas may also contribute to the high potassium content in these soils (Tisdale et al., 1990).

The significantly lower content (0.07%) of total potassium in lateritic alluvial soils may be due to the predominance of 1:1 type minerals which do not fix potassium in them.

The exchangeable potassium in soils also showed a similar trend, with Kuttanad soils containing higher exchangeable potassium than lateritic alluvial soils. The high CEC of soils resulting from the mineral and organic matter constituents may be responsible for holding a higher amount of potassium in exchangeable form.

In all these soils, though the contribution of SOM to total and exchangeable potassium is very low, it is positively correlated to total and available potassium (figures 11 and 15). The fractions of SOM also showed a positive correlation with potassium in Karappadam soils, which may be explained by the presence of the highest quantity of humic acid fraction in them. The K^+ ions are reported to be bound specifically to HA fraction of SOM and the sites per gram of HA was greater for K^+ ion than that for any other alkali metal cations. (Bonn and Fish, 1993). This may be the reason for high correlation of potassium with SOM and its fractions in the Karappadam soils.

The results show that, in all these wetland soils, the influence of SOM on total and available potassium is very low as a major part of these are associated with mineral colloids.

5.5.4. CALCIUM

Calcium in soil exist as a structural component of primary minerals like anorthite and in exchangeable forms, held on the surface of negatively charged clay and organic colloids. The availability of calcium is controlled by the type of clay mineral, CEC and organic matter content. Usually soils with high organic matter, CEC and a high content of 2:1 type minerals contain more calcium in exchangeable form.

The results of the study revealed that Kuttanad soils contain relatively higher calcium (0.36%) than lateritic alluvial soils (0.09%). This higher content of total calcium in Kuttanad soils, inspite of high acidity, may be attributed to the presence of limeshells in the soil horizons. The contribution of organic matter to total calcium is found to be very low in all these soils, ranging from 1.0 to 7.7%.

The exchangeable calcium content also showed a similar trend. The high CEC, organic matter and 2:1 type minerals help the Kuttanad soils to retain calcium in exchangeable forms whereas the low CEC, low organic matter and predominance of 1:1 type minerals make the Pattambi soils low in exchangeable calcium. The contribution of organic matter to exchangeable calcium is also low in all the four soils.

In all these soils, total and exchangeable calcium is positively correlated to SOM and its fractions (figures 12 and 16).

As in the case of potassium, calcium status is also influenced only to a low degree by the SOM content in the wetland soils.

5.5.5. **MAGNESIUM**

Magnesium exists in soil as a structural component of clay minerals, as fixed in between the layers of 2:1 type minerals and in exchangeable forms. The exchangeable forms are held on the surface of clay and organic colloids. The magnesium associated with SOM occurs mainly in an exchangeable form on its negatively charged surface. The total and available forms of magnesium in Kuttanad soils (0.15% and 1.4 Cmol kg^{-1} respectively) are significantly higher than those in lateritic alluvial soils (0.03% and 0.15 cmol kg^{-1} respectively). The contribution of organic matter to total and exchangeable magnesium are meagre, as most part of it is associated with the mineral matter in soil. However, total as well as exchangeable magnesium in all these soil types are positively correlated with SOM and with its fractions (figures 13 and 17).

Like potassium and calcium, magnesium status both total and exchangeable is influenced to a low degree by the SOM content in the wetland soils.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Kari, *Karappadam*, *Kayal* and lateritic alluvial soils representing the typical wetland soil types of Kerala were analysed to establish the precise relationship between organic matter and important soil characters. Destruction of organic matter in all the soil types has lead to an appreciable change in almost all soil properties indicating the significant role of SOM in controlling the fertility and productivity of these soils.

The SOM in the soil samples was separated and fractionated to non-humified organic matter, humified organic matter, humic acid and fulvic acid. The correlation between various soil properties and SOM and its fractions was worked out and regression equations for important soil characters derived. The salient results and conclusions drawn from the study are summarised.

1. Among the four wetland soil types, the organic matter content is highest in *Kayal* soils with a mean of 8.03%, followed by *Kari* soils with a mean value of 7.58%. *Karappadam* soils have an average content of 6.81% organic matter and the lateritic alluvial soils are low in organic matter registering a mean value of only 2.24%.

The organic matter content in all the four soil types showed considerable degree of variability between samples. The CV is maximum in _Kari_ soils (44.7%) and minimum in _Kayal_ soils (21.2%).

2. The humified fraction of SOM (separated by extraction with alkali) is maximum in _Karappadam_ soils (72.8%) followed by _Kayal_ (60.4%), _Kari_ (56.2%) and lateritic alluvial soils (53.1%).

3. Humic acid content of the humified organic matter is maximum in _Karappadam_ soils, followed by _Kayal_ and _Kari_ soils. The lateritic alluvial soils contained the lowest quantity of HA.

4. The fulvic acid content of humified organic matter is maximum in _Kayal_ soils and minimum in lateritic alluvial soils, with _Kari_ and _Karappadam_ soils showing intermediate values.

5. In all the soil types, except the _Kari_ soil, the HA/FA ratio is less than unity, indicating a high degree of degradation of humus resulting in a faster conversion of HA to FA. However, in _Kari_ soils, the ratio exceeded unity, suggesting a slower rate of conversion of HA to FA. This is probably due to the highly acidic conditions prevalent in the _Kari_ soils.

6. The nature of SOM in _Kayal_ soils appears to be different from that in other soil types, as evident from its comparatively lesser contribution to pH, WHC, CEC, lime requirement and status of nutrients. The correlation between SOM and these soil properties which are positive but not significant lend support to this view. The SOM in _Kayal_ soils may probably exist as stable clay-humus-complexes which are inaccessible for exchange reactions and nutrient interactions.

7. The _Kari_, _Karappadam_ and _Kayal_ soils are highly acidic with pH values ranging from 3.2 to 4.7, 3.9to 4.9 and 3.4 to 4.6 respectively. The lateritic alluvial soils are less acidic with a mean pH of 5.6. pH values showed the least variability between samples in all soil types and presented a negative relationship with SOM as well as with its fractions. The average contribution of soil organic matter to pH is high in _Karappadam_ (18.4%) and _Kayal_ soils (17.2%) and low in lateritic alluvial soils (4.2%). Inspite of the high content of SOM in the _Kari_ soils, its contribution to pH is only 7.1%. This is attributed to the poor deprotonation or ionisation of functional groups in SOM at the existing acidic soil conditions.

8. Lime requirement is highest in _Kayal_ soils (30.7tha^{-1}) and lowest in lateritic alluvial (9.7tha^{-1}) soils with _Kari_ and _Karappadam_ soils recording intermediate values. Destruction of organic matter in all these soils has resulted in a reduction in lime requirement (13.9 to 25.5%) indicating the major role of SOM in contributing to the acidity of soils.

9. _Kayal_ soils have the highest WHC (80.8%) and the lateritic alluvial soils the lowest (44.4%). _Kari_ (69.3%) and _Karappadam_ (71.8%) soils recorded intermediate values. Maximum contribution by SOM is made in the lateritic alluvial soils (49.8%) followed by _Karappadam_ (29.4%) _Kayal_ (25.3%) and _Kari_ (24.7%) soils. The oxidic and kaolinitic minerals which are abundant in the lateritic alluvial soils are contributing to 50% of the WHC and the remaining half is contributed by SOM. The WHC of individual soils in all soil types showed a variability ranging from 7.2 to 14.9%. WHC is positively correlated to SOM and to its different fractions in all soil types.

10. CEC is highest in _Kari_ soils (19.0 Cmolkg^{-1}) and lowest in the lateritic alluvial soils (7.0 Cmolkg^{-1}) with _Karappadam_ and _Kayal_ soils showing intermediate values of 15.4 and 18.1 Cmolkg^{-1}. CEC of samples of each soil type showed considerable variability with CV values ranging from 9.3% in

Kayal soils to 37.5% in Kari soils. The contribution of SOM to CEC is maximum in Kari soils (27.2%) followed by Karappadam (19.6%) and lateritic alluvial soils (16.8%) and it is least in Kayal soils (9.7%).

11. The CEC of all soils except Kayal soils showed significant and positive linear relationship with SOM as well as with its fractions. The lack of such a relationship in Kayal soils is attributed to the masking effect of stable clay-humus-complexes as explained earlier.

12. The Kari, Karappadam and Kayal soils are highly buffered when compared to the lateritic alluvial soils. The high content of SOM and exchangeable aluminium and predominance of 2:1 type clay minerals make the Kari, Karappadam and Kayal soils highly buffered compared to the lateritic alluvial soils. The low content of SOM, absence of acid forming minerals and the predominance of 1:1 type clay minerals have caused only a poor buffering action in the lateritic alluvial soils.

13. Destruction of SOM has caused a drastic reduction in the degree of slope of the buffer curves for Kari, Karappadam and Kayal soils. This indicates the influence of SOM in maintaining these soils in a highly buffered state.

14. Total nitrogen is maximum in Karappadam soils with a mean value of 0.32%. Lateritic alluvial soils have 0.22% nitrogen and Kari soils 0.28%. The total nitrogen content in individual soil samples within each group showed high degree of variability ranging from 26.3 to 35.4%. The available nitrogen is highest in Kari soil (469.6 $Kgha^{-1}$) followed by Kayal (441.8 $Kgha^{-1}$), lateritic alluvial (434.0 $Kgha^{-1}$) and Karappadam (421.6 $Kgha^{-1}$) soils. The available nitrogen in individual samples of each soil type on the other hand showed only a slight variability ranging from 10.9 to 16.9%.

15. In all soil types, SOM contributed to more than 90% of the total and available nitrogen, which are positively correlated to SOM and its fractions. The positive correlation of nitrogen with SOM which was not significant in Kari, Karappadam and Kayal soils indicate the possible occurence of nitrogen in stable forms other than easily hydrolysable amino acids.

16. Total phosphorus is maximum in Kayal soils (0.143%) followed by lateritic alluvial soils (0.117%), Karappadam (0.077%) and Kari (0.044%) soils. The individual soils differ considerably in their total phosphorus content (CV = 21.2 to 39.0%). The contribution of SOM to total phosphorus is maximum in Kari soils (35.2%) and minimum in Kayal soils

(5.4%). Karappadam and lateritic alluvial soils showed intermediate values of 9.8 and 10.4% respectively. In all the four soil types, total phosphorus is positively correlated to SOM, HA and FA.

17. The available phosphorus content in all the soil types showed maximum degree of variability within each group (85.1 to 160.8%). It ranged from traces to 8.96 $Kgha^{-1}$ in Kari and Kayal soils and from traces to 31.36 $Kgha^{-1}$ in Karappadam soils. In lateritic alluvial soils the available phosphorus ranged between 8.96 and 190.4 $Kgha^{-1}$. The highest content of available phosphorus is seen in the lateritic alluvial soils.

18. Inspite of the high content of organic matter, the available phosphorus in Kari, Karappadam and Kayal soils is comparatively low and it showed a negative correlation with SOM. This is probably due to the strong linkage of phosphorus with humus via iron and aluminium bridges which make them less susceptible to mineralization processes which render the organic phosphorus available. In lateritic alluvial soils, available phosphorus is positively related to SOM and its fractions suggesting the absence of such strong linkages which prevent the mineralization of organically bound phosphorus.

19. Total potassium is maximum in Kayal soils (0.42%) and minimum in lateritic alluvial soils (0.07%) with Kari and Karappadam soils recording intermediate values. Exchangeable potassium is highest in Kayal soils (358.4 $Kgha^{-1}$) and minimum in lateritic alluvial soils (118.3 $Kgha^{-1}$). The total and exchangeable calcium and magnesium is highest in Kayal soils and minimum in lateritic alluvial soils.

20. In all the four soils types, though the contribution of SOM to total and exchangeable potassium, calcium and magnesium is very low, they are positively correlated to each other. The study has revealed that the content of total and exchangeable potassium, calcium and magnesium are influenced only to a very low degree by SOM.

In all the wetland soil types, the pattern of relationship of each soil property with SOM is found to be more or less the same as that between its different fractions. The results of the study further revealed that the relationship between SOM and soil properties seems to be as valid as its relationship with the different fractions of SOM. When all the wetland soils types are considered together, all soil properties except pH showed a strong positive and significant correlation with SOM which was not so pronounced when the individual soil types were considered. The spatial variability of the respective samples of each soil type may be considered responsible for the lack of a significant relationship between some of the soil properties and organic matter in individual soil types. The results of the study has lead to certain suppositions on the forms in which humus and organically bound nitrogen and phosphorus exist in the wetland soils. Future work on the fractionation of organically bound nitrogen and phosphorus in these soils will be useful to get affirmative results on these aspects.

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* Originals not seen.

INTERRELATIONS OF HUMUS WITH THE FERTILITY COMPONENTS OF WETLAND SOILS

BY

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ABSTRACT OF A THESIS

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ABSTRACT

Surface soil samples from the major wetland soil types of Kerala were studied to establish the relationship between soil organic matter and its fractions with the total and available nutrients and other physicochemical characters.

Destruction of organic matter has resulted in a substantial drop in the status of almost all nutrients and an appreciable change in soil properties. The SOM separated from the soils were fractionated and the correlation between soil characters and the SOM and its fractions were determined. Regression equations relating soil properties which were significantly correlated with SOM and its fractions were also derived in each soil type.

The study has revealed that CEC, WHC, SOM, lime requirement, buffering capacity as well as total and available nutrients in all the four soil types showed considerable degree of variability between samples in each soil type.

The content of SOM was highest in *Kayal* soils (8.03%) and lowest in lateritic alluvial (2.24%) soils with *Kari* and *Karappadam* soils with intermediate values of 7.58 and 6.81% respectively

Fractionation of organic matter has shown that humification of SOM was maximum in *Karappadam* soils, followed by *Kayal*, *Kari* and lateritic alluvial soils. The degree of degradation of humified organic matter was high in all the soil types except *Kari* soils, as evidenced from the HA/FA ratios.

The SOM in *Kayal* soils may probably exist as a stable clay-humus complex which has resulted in its lower contribution to CEC, lime requirement and nutrient status.

All the four soil types were acidic and the contribution of SOM to free acidity was maximum in *Karappadam* soils (18.4%) followed by *Kayal* (17.2%) and lateritic alluvial soils (4.2%). Inspite of the high content of SOM, its contribution to free acidity in *Kari* soils was only 7.1%, probably due to the low deprotonation of SOM at low pH values. pH in all soil types is negatively correlated to SOM and its fractions. The *Kari*, *Karappadam* and *Kayal* soils are highly buffered when compared to lateritic alluvial soils and the slope of the buffer curves for these soils showed a drastic drop due to the destruction of organic matter.

The contribution of SOM to lime requirement ranged from 13.9 to 25.5% which is evident from the drastic drop in lime requirement values consequent to the destruction of organic matter.

Maximum contribution of SOM to WHC was shown by lateritic alluvial soils (49.8%). In _Kari_, _Karappadam_ and _Kayal_ soils, the contribution was 24.7, 29.4 and 25.3% respectively. WHC is positively related to SOM and its fractions in all the soils.

CEC was highest in _Kari_ soils and lowest in lateritic alluvial soils. The contribution of SOM to CEC was maximum in _Kari_ soils (27.2%) and least in _Kayal_ soils (9.7%). CEC of all soils except _Kayal_ soil showed significant positive and linear relationship with SOM as well as with its components. The lack of such a relationship in _Kayal_ soil is attributed to the existence of stable clay-humus-complexes.

Karappadam soils showed the highest content of total nitrogen and lateritic alluvial soils the lowest. Available nitrogen was highest in _Kari_ soils and lowest in _Karappadam_ soils. In all the four soil types, SOM contributed to more than 90% of total and available nitrogen and it is positively correlated to total and available nitrogen.

Total phosphorus was highest in _Kayal_ soils and lowest in _Kari_ soils. Inspite of the lowest content of SOM in _Kari_ soils, it made the maximum contribution to total phosphorus (35.2%). In the _Kayal_ soils the contribution of SOM to total phosphorus was minimum and representing only 5.4%.

The available phosphorus in all the soil types showed maximum degree of variability (85.1 to 160.8%) between samples and the contribution of SOM to available phosphorus was also very low. It showed a negative correlation with SOM and its fractions in Kari, Karappadam and Kayal soils probably due to the strong linkage of phosphorus to humus via iron and aluminium bridges. In lateritic alluvial soils, the relationship between SOM and available phosphorus was positive.

The total and exchangeable potassium, calcium and magnesium are positively correlated to SOM and its fractions. However, these are influenced only to a very low degree by the SOM content.

The pattern of relationship of each soil property with SOM is the same as that with its fractions and hence, in studies on soil organic matter, the derivation of relationship between soil properties and soil organic matter alone is sufficient to bring out the interaction between soil organic matter and components of soil fertility.