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Soil Quality Assessment at Padre Micro Watershed, Kasaragod Kerala Using Geomatics

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Abstract

In this paper, study is mainly soil quality profile of lateritic soil since Southern part of Karnataka and Kerala is mainly varied with red soil and lateritic soil and also has major production of cash crops like coconut, areca-nut and rubber. Agriculture is an important enterprise of Kasaragod district Kerala, India. For the collected soil sample, basic soil tests such as moisture content, bulk density, grain size analysis and physicochemical parameters like pH, electrical conductivity, macronutrients organic carbon, nitrogen, phosphorus and potassium were performed and results were calculated. The secondary nutrients like calcium and magnesium content of soil are analyzed. Results were interpreted from the spatial variation maps. The soil texture of the soil in the Padre micro watershed area is of sandy clay with very less percentage of silt. The percentage clay in soil ranges from 28% to 63%. Clay level will influence the behaviour of organic and inorganic pollutants in soil. The nature of the soil is acidic in pre-monsoon and post-monsoon. Generally, this characteristic feature is very common in lateritic soils. It is observed that organic content in the study area is in the range of 0.06 to 3.36% during the pre-monsoon season, and the values range of 0.1 to 3.8% during the post-monsoon season. Increased soil organic carbon and exchangeable bases are influenced by the vegetation, climate, altitude, and soil minerals, respectively. Another potential cause of the soil's pH being lowered is the existence of a larger concentration of organic materials. The decreased value of total nitrogen in organic plots may be due to crop uptake, microbial immobilization, and volatilization.

***Key words*:** Macronutrients, Organic carbon content, Soil texture, ArcGIS, IDW

Soils are heterogeneous mixture of several components like organic and inorganic compounds of varying compositions. Soils are the source of many different life is the most important natural resource, and nonrenewable in short interval of time. Soil characteristics are dynamic natural property and it may change by the influence of natural and human induced factors. Due to continue increase in human population, human disturbance on the earth's ecosystem to produce food and fiber will place greater demand on soils to supply essential nutrients. Soil characteristics are dynamic and subject to change due to various factors, both natural and human-induced. Human activities such as agriculture, urbanization, and industrialization can significantly impact soil quality and fertility. Continuous cropping, a common practice in agriculture aimed at maximizing yield, can deplete soil nutrients over time. When crops are harvested, they remove essential nutrients from the soil, and if these nutrients are not replenished adequately, soil fertility can decline. This can lead to decreased agricultural productivity and increased reliance on synthetic fertilizers, which can have negative environmental consequences such as nutrient runoff and soil degradation. Continuous cropping for enhanced yield removes substantial amounts of nutrients from soil. Imbalanced and inadequate use of chemical fertilizers, improper irrigation and various cultural practices also deplete the soil quality rapidly [13].

Soil fertility fluctuates throughout the growing season each year due to alteration in the quantity and availability of mineral nutrients by the addition of fertilizers, manure, compost, mulch, and lime in addition to leaching. This can reduce soil fertility over time, especially if not replenished through fertilization. To mitigate the depletion of nutrients from soils, sustainable agricultural practices such as crop rotation, cover cropping, and organic farming can be employed. These methods help to replenish soil nutrients, improve soil structure, and promote overall soil health. Additionally, proper soil management techniques, including soil testing and nutrient management planning, can help farmers make informed decisions about fertilization and ensure that soil nutrients are maintained at optimal levels for crop growth. Integrating organic sources of nutrients such as compost, manure, cover crops, and crop residues with synthetic fertilizers can improve soil health and fertility over the long term. This approach enhances nutrient cycling, reduces dependence on external inputs, and promotes sustainable agricultural practices. Hence, evaluation of fertility status of the soils of an area or a region is an important aspect in the context of sustainable agriculture. The physico-chemical study of soil is very important because both physical and chemical properties which affect the soil productivity. The physico-chemical study of soil is based on various parameters like pH, electrical conductivity, texture,

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moisture, temperature, soil organic matter, available nitrogen, phosphorus and potassium. This knowledge will create awareness among the farmers about economic productivity [15].

MATERIALS AND METHODS

The study area Padre micro watershed of Enmakaje Panchayath lies in the Kasaragod District is the northernmost district of Kerala State and is bound between the north latitudes 12°02′27″ and 12°47′35″ and east longitudes 74°51′54″ and 75°25′25″. The district is agrarian with cash crops of Areca nut, cashew and rubber dominating over food crops. Kasaragod district is an area, which receives maximum rainfall in the state in a short duration during southwest monsoon and northeast monsoon periods. Though this area receives large quantity of rainfall, the same area suffers maximum due to drought. Geologically Kasaragod area predominantly occupies by crystalline rocks and is widely lateritic. In 2018-2019 pre-monsoon and post-monsoon a total 21 soil samples were collected from the field through random sampling from whole of the study area. A portable global positioning system (GPS) was used to collect each sample site. (Fig 1) study area and (Fig 2) shows the soil sample location map.

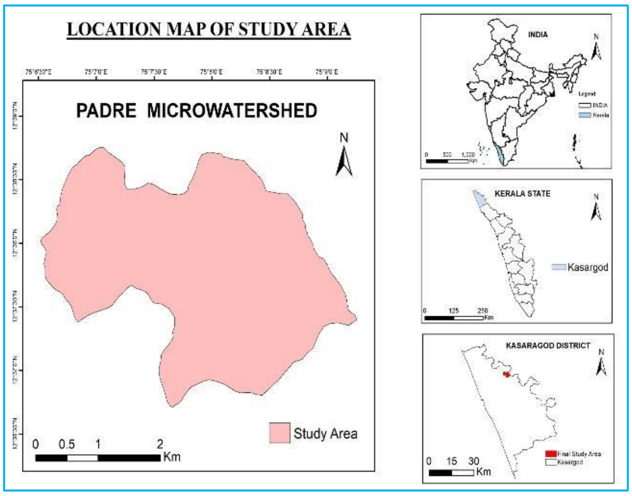

Fig 1 Study area

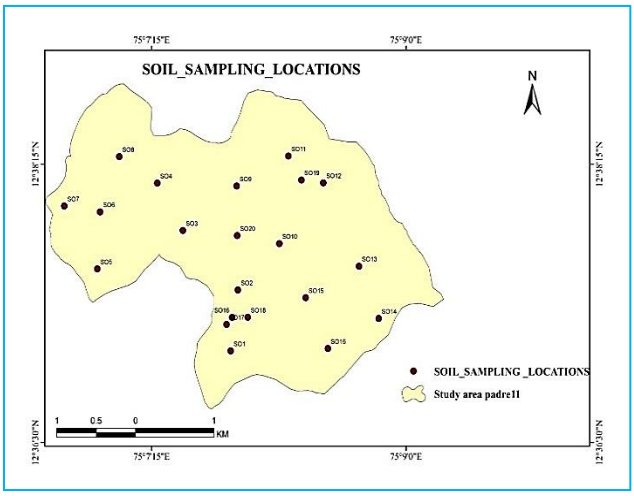

Fig 2 The soil sampling location map

Soil sampling

Soil samples are collected in pre-monsoon season and post monsoon seasons analyzed for physical and chemical properties. Representative samples of the area were selected for the study. Soil sampling was done by the method of quarter method. A 10'x10' area was cleaned and divided into 4 quartets. About 1kg of the soil was collected from 0-20cms depths 2 opposite quartets into plastic trough. It was then well mixed and again divided into 4 quartets. The soil from opposite quartets was collected and was further reduced to ½ kg and stored in polythene covers. 20 samples were collected from different field locations of the study area. A portable global positioning system was used to collect each sample site. The well mixed soil samples were air dried and passed through a 2mm sieve for laboratory analysis. Figure 3 and 4 shows soil sampling photographs and flow chart of methodology of soil sampling and quality analysis.

Sieve analysis as per ASTM D 422 [1] is performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method is used to determine the distribution of the finer particles. Grain size analysis for grain size distribution was carried out for classifying the soil. Moisture content of the soil was conducted as per ASTM D 2216 [2]. Bulk density of soil in-situ by core cutter method, as per BIS: 2720 part 21 1975 [6].

Soil samples were analyzed for soil pH in both water and 0.01 M potassium chloride solution (1:1) using glass electrode pH meter [Madison: American society of Agronomy1965]. Total nitrogen was determined by the macro-kjeldahl digestion method [Jackson 1958]. Available P was determined by the method described by Olsen [Jackson 1958] [8]. Organic carbon content (OC) was measured by the Walkley-Black method [Madison: American society of Agronomy1965] [7]. Conversions between values of organic carbon and organic matter was made using Van Bemmelen factor of 1.724 on the assumption that, on average, SOM contains 58% of organic C. Exchangeable cations were extracted with 1 M NH_4OAC (pH 7.0) to determine K and Na using flame photometer and exchangeable Mg and Ca by atomic absorption spectrophotometer [Madison: American society of Agronomy1965].

Fig 3 Soil sampling

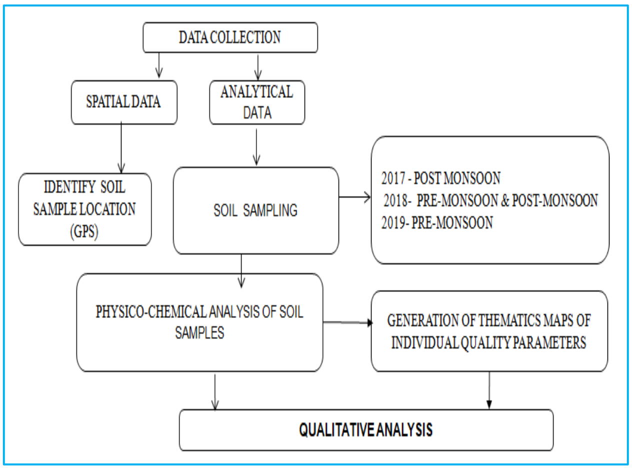

Fig 4 Flow chart showing the methodology of soil sampling

RESULTS AND DISCUSSION

Physicochemical characteristics

Results were interpreted from the spatial variation maps and Inverse Distance Weighting (IDW) interpolation methods in the geostatistical analyst tool of ArcGIS 10.4 software was used.

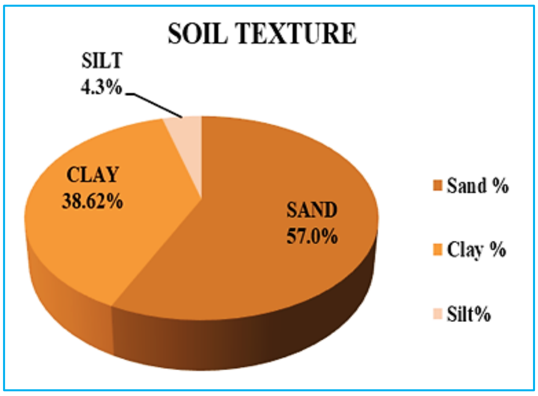

Fig 5 Study area soil texture classification

Soil texture

Soil texture directly influences soil-water relations, aeration, and root penetration. Soil texture has an effect on the amount of nutrients in the soil. The clay content of the soil in the study area ranges from 36.5 to 63%. Clay contents are known to influence the dynamics and behaviour of both organic and inorganic pollutants in soil. The silt content is in the range of 3.6 to 4.9%. The sand content is in the range of 33 to 67% in the study area. (Fig 5) shows the overall soil classification based on particle size distribution. It is observed that the average clay content in study area is 38.62%, sand of 57% and less silt content of 4.3%.

Organic carbon content

It is observed that organic content in the study area is in the range of 0.06 to 3.36% during the pre-monsoon season, and the values range from 0.1 to 3.8% during the post-monsoon season. The iso-variation map of soil organic content is depicted in figures 6 a and b during both pre-monsoon and post-monsoon seasons. Increased soil organic carbon and exchangeable bases are influenced by the vegetation, climate, altitude, and soil minerals, respectively.

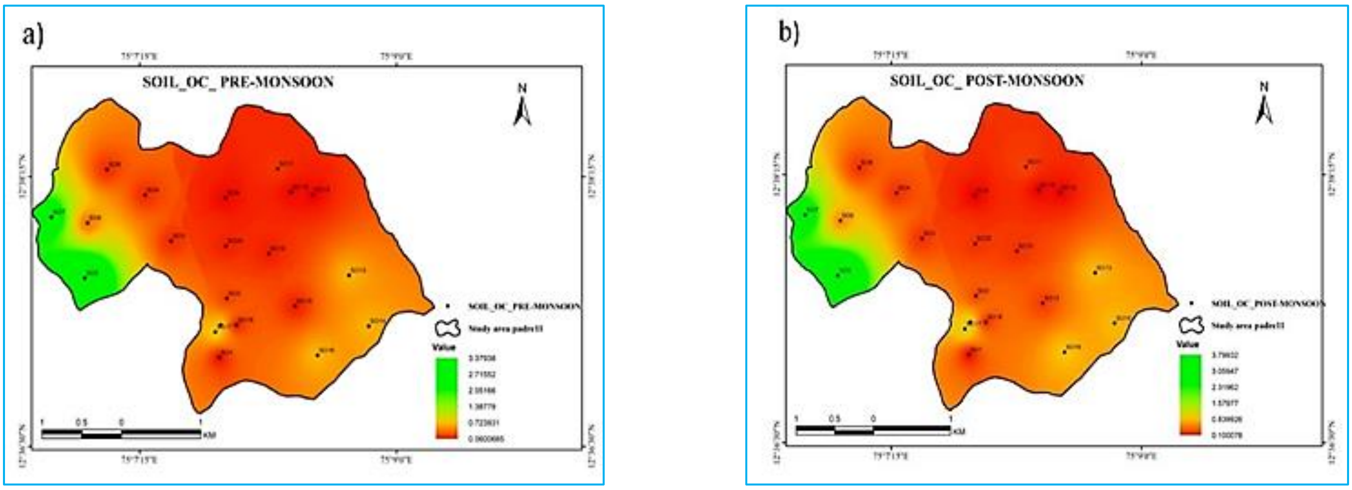

Fig 6 organic content distribution (a) PRM and (b) POM

Soil moisture content

The soil's ability to absorb nutrients is mostly dependent on the moisture level of the soil, which also affects the soil's texture. Organic matter frequently increases a field's capacity for water and the amount of water that is readily accessible in sandy soil. The capacity of soil organic matter to hold water and absorb cations is unparalleled, and it also provides vital nutrients. A soil's ability to store water indicates how physically sound it is. The soil moisture content during pre-monsoon was in the range of 18–26.3% and during post-monsoon, 19–28%. An Iso-variation map of soil moisture content in the study area during pre-monsoon and post-monsoon is depicted (Fig 7 a-b).

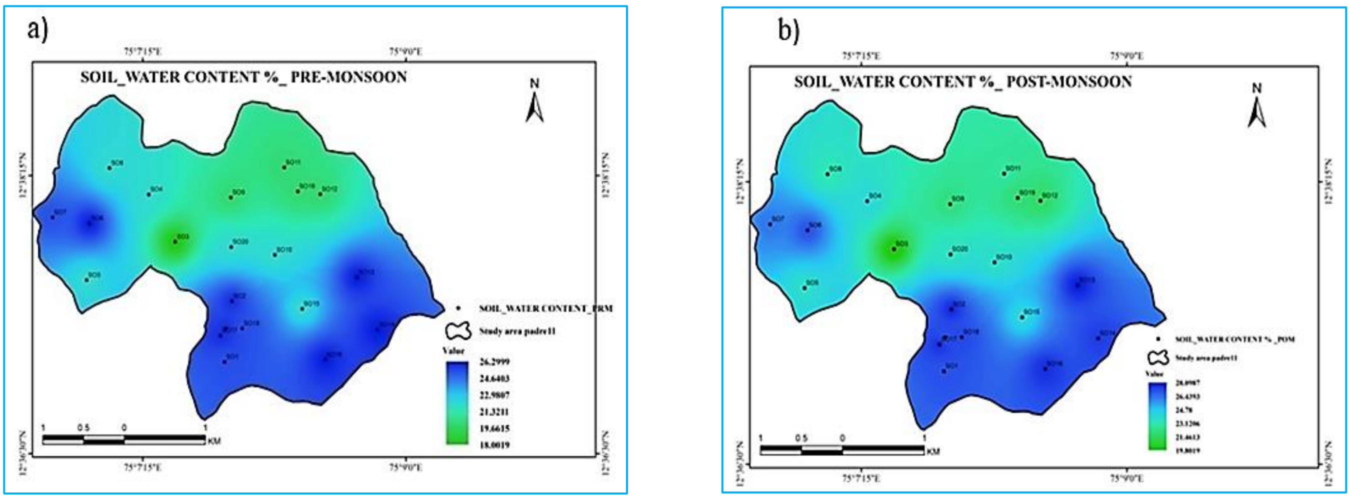

Fig 7 Organic content distribution (a) PRM and (b) POM

pH

The most significant property of soil is its pH level, its effects on all other parameters of soil. Therefore, pH is considered while analyzing any kind of soil pH is a crucial factor because it ensures the availability of nutrients for plants; for instance, Fe, Mn, Zn, and Cu are more readily available in acidic soils than in alkaline ones. pH is a reliable indicator of whether soil nutrients are in balance. It is also an indicator of plant and other living organisms, available nutrients, cation exchange capacity, and organic matter content. Williams investigated how pH affects nutrient balance and discovered that a high pH can affect the amount of micro-nutrients in the soil. Micronutrients are highly soluble at low pH levels, while they become less soluble and less available to plants at high pH levels. pH values in the study area range from 4.3 to 6.67 during the pre-monsoon season and 5.2 to 7.1 during the post-monsoon season. The results indicate that all the soil samples in the study area were acidic in nature. The pH levels of soils in a given area allows for targeted management practices to adjust soil acidity or alkalinity as needed to support healthy plant growth and sustainable agricultural production. An iso-variation map of the soil pH of the study area is depicted in (Fig 8 a-b).

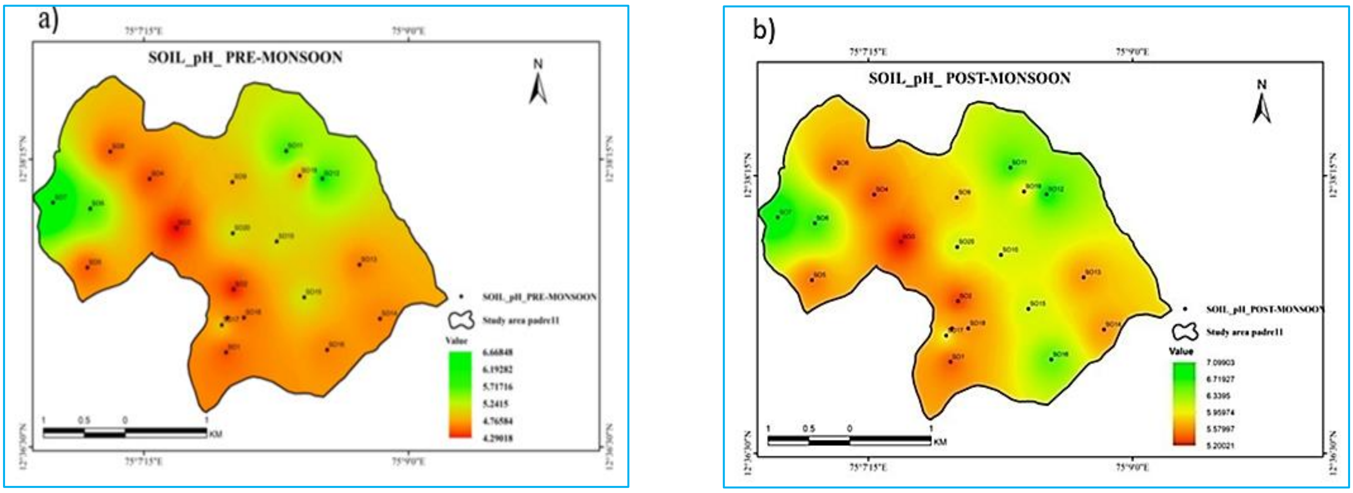

Fig 8 pH distribution (a) PRM and (b) POM

Electric conductivity

Electric conductivity is a quick, easy, and affordable way to assess the health of soils. It measures the number of ions in a solution. A soil solution's electrical conductivity rises as the concentration of ions does. It is a measurement that is related to factors in soil that determine subsurface characteristics like salinity, organic matter content, cation exchange capacity, drainage, and soil texture. The amount of moisture that soil particles can hold has an impact on the electrical conductivity of the soil. It is helpful for keeping an eye on the soil's organic matter mineralization. It is a typical soil since the electrical conductivity is less than 1 (dS/cm) [15]. At the study sites, the soil's electric conductivity was recorded at 0.01 to 0.02 dS/m. An Iso-variation map of soil moisture content in the study area during pre-monsoon and post-monsoon is depicted in (Fig 3.6 a-b).

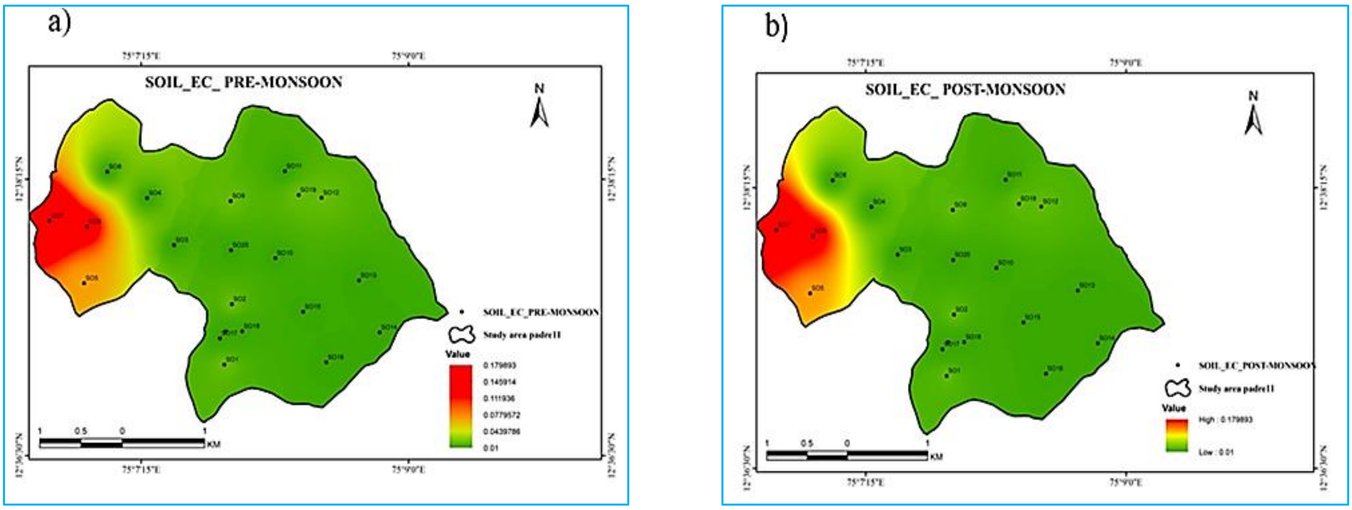

Fig 9 EC distribution (a) PRM and (b) POM

Nitrogen content of soil

The levels of nitrogen, phosphorus, and potassium in the soil play a key role in agricultural areas. The most essential fertilizer component is nitrogen which promotes the growth above-ground vegetation and gives leaves a rich green hue. Plants absorb nitrogen as NO_3 and NH_4. Being a component of all proteins, enzymes, and metabolic processes involved in the synthesis and transmission of energy. It is also a component of all living cells. Nitrogen is necessary for plant growth and is a component of nucleic acid, chlorophyll, and plant proteins. Nitrogen affects how well plants produce fruit and raises the fruit's protein content. In addition to moisture conservation, the availability of nitrogen from both organic and inorganic sources is important for increased winter sorghum output. The decreased value of total nitrogen in organic plots may be due to crop uptake, microbial immobilization, and volatilization [15].

Pre-monsoon soil nitrogen content ranges from 0.84 to 4.85kg/ha, while post-monsoon soil nitrogen content ranges from 0.78 to 4.2kg/ha. Managing nitrogen fertility is critical for optimizing crop yields, promoting plant health, and ensuring sustainable agricultural practices. Balancing nitrogen inputs with crop demand, soil conditions, and environmental considerations is essential for maximizing nitrogen use efficiency and minimizing nutrient losses to the environment.

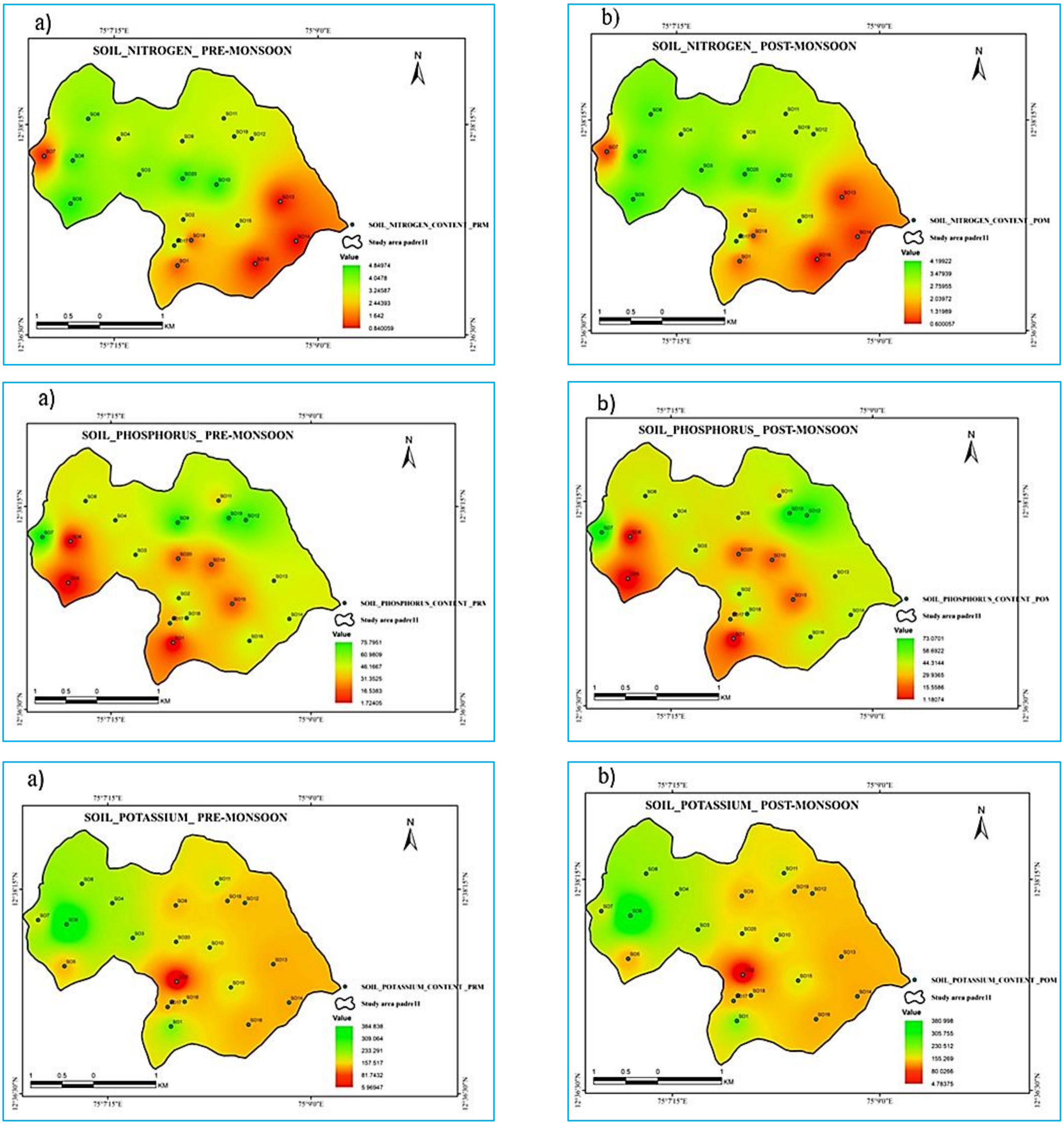

Fig 10 N, P and K distribution (a) PRM and (b) POM

Phosphorus content of soil

In laterite soils, phosphorus leaches out very slowly. High rainfall would result in an increase in phosphorus. According to reports, phosphorus is the primary nutrient that limits productivity in tropical regions, particularly in the laterite soils of Kerala [5]. Each and every live cell in a plant contains phosphorus. It is one of the most crucial micronutrients required for plant development. Most often, phosphorus is the nutrient that persists in plant nuclei and functions as a form of energy storage. It facilitates energy transfer. Due to the significant amount of phosphorus needed for plant growth, phosphorus is a crucial element. It is also a crucial step in the creation of all lipids, sugars, starches, and other compounds during photosynthesis. Phosphorus is widely distributed in plant seeds and fruits and is essential for many physiological processes in plants. The accessible phosphorus content of the soil was higher in higher topographic positions than in lower topographic positions. In comparison to soils with low levels of organic matter, soils with high levels of organic matter provide greater sources of organic phosphate for plant uptake [15]. Phosphorous availability to plants would rise with heavy precipitation. According to reports, phosphorus is the primary nutrient that limits productivity in tropical areas, particularly in the laterite soils of Kerala [5]. The value of phosphorus content is in the range of 1.16 to 75.85 kg/ha during pre-monsoon seasons and 1.12 to 73.1 kg/ha during post-monsoon seasons.

Potassium content of soil

Laterite soil is typically thought to contain less potassium. However, there has been a general increase in potassium availability across all regions and throughout all the seasons. Although potassium is not a major component of any major plant parts, it is essential to a wide range of physiological processes, including protein synthesis and the maintenance of the water balance in plants. The use of potassium fertilizers and the addition of manures may be responsible for the high availability of potassium in surface soil. Laterite soil is typically thought to be low in potassium [15]. The potassium content of soil in the study area ranges from a minimum of 4 kg/ha to a maximum of 383kg/Ha during the pre-monsoon season and from a minimum of 5.97 kg/ha to a maximum of 384.83 kg/ha during the post-monsoon season. Potassium is an essential nutrient for plant growth and productivity, and its availability in soil plays a critical role in supporting healthy plant development and crop yields, even in soils traditionally considered low in potassium like laterite soils.

Calcium (Ca) and magnesium (Mg) content of soil

Calcium (Ca), and magnesium (Mg) are considered as secondary nutrients in soil. In a highly weathered tropical soils concentration of calcium nutrients is very less. As calcium affects numerous physico-chemical, and biological processes, it is crucial that soils have adequate calcium content. Micro-organisms fix nitrogen are essentially non-existent in acidic soils with less calcium levels. The calcium concentrations in the soil of study area ranges from 500 kg/ha to 600 kg/ha.

Magnesium concentration in the soil generally helps in photosynthesis process of plants since it is a key component of chlorophyll. The magnesium concentration in the soil ranges from 5 kg/ha to 900 kg/ha. (Fig 11) shows the spatial distribution of Ca and Mg in the study area during a) pre-monsoon (PRM) and b) post-monsoon (POM).

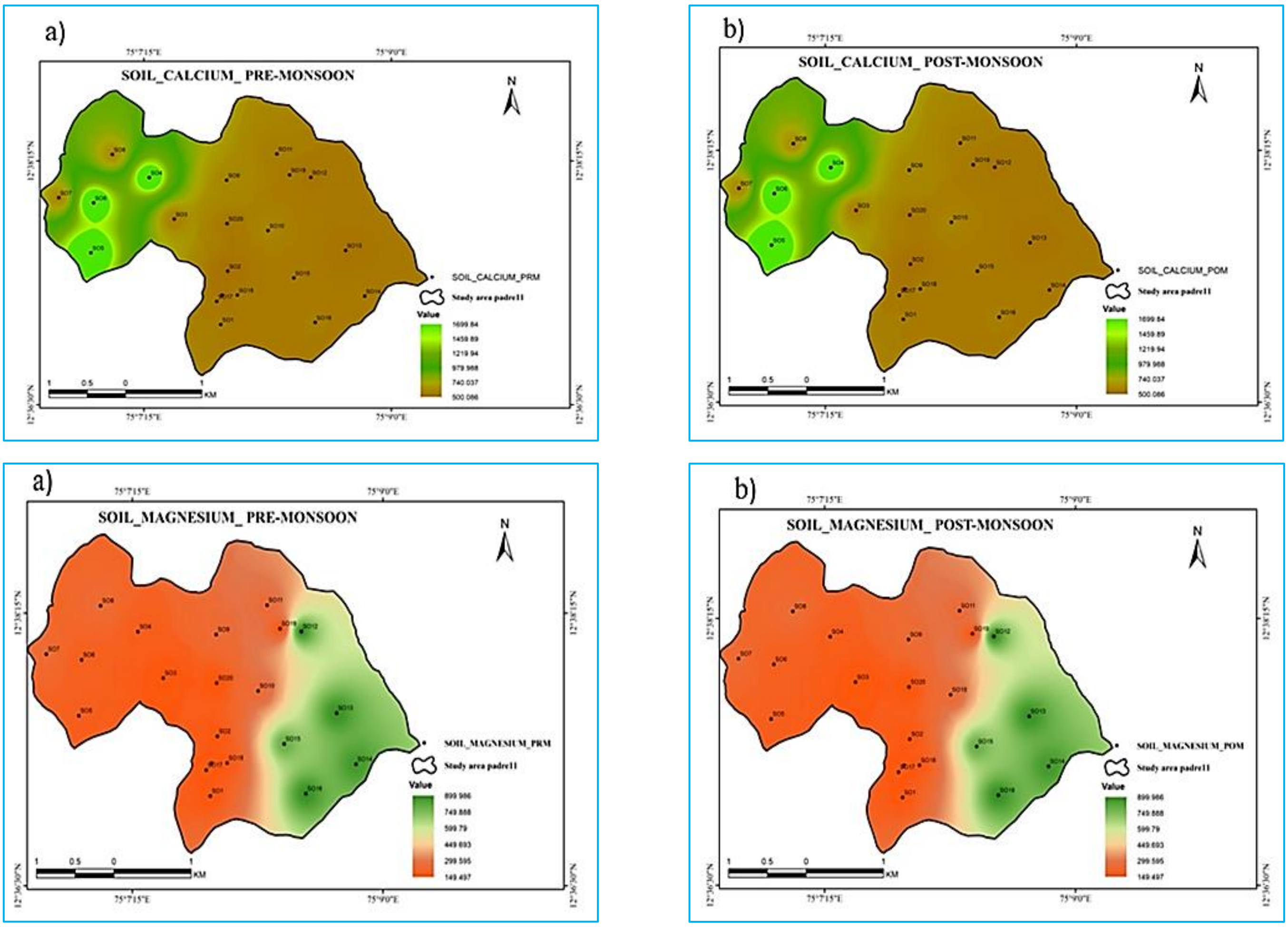

Fig 11 Ca and Mg distribution (a) PRM and (b) POM

CONCLUSION

The soil texture of the soil in the Padre micro watershed area is of sandy clay with very less percentage of silt. The percentage clay in soil ranges from 28% to 63%. Clay level will influence the behaviour of organic and inorganic pollutants in soil. The nature of the soil is acidic in pre-monsoon and post-monsoon. Generally, this characteristic feature is very common in lateritic soils. It is observed that organic content in the study area is in the range of 0.06 to 3.36% during the pre-monsoon season, and the values range of 0.1 to 3.8% during the post-monsoon season. Increased soil organic carbon and exchangeable bases are influenced by the vegetation, climate, altitude, and soil minerals, respectively. Another potential cause of the soil's pH being lowered is the existence of a larger concentration of organic materials. The decreased value of total nitrogen in organic plots may be due to crop uptake, microbial immobilization, and volatilization. The nitrogen nutrient in the soil easily leached out by rain water and irrigation water. The use of potassium fertilizers and the addition of manures may be responsible for the high availability of potassium in surface soil. In comparison to soils with low levels of organic matter, soils with high levels of organic matter provide greater sources of organic phosphate for plant uptake.

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