# Assessment and GIS Mapping of Soil Quality Indicators of Agroecological Unit 9 of Kerala, India


## ABSTRACT

**Context:** The agroecological unit 9 (AEU 9) in Alappuzha district of Kerala represents the south central laterites. The soils are acidic, gravelly, having low activity clay, often underlain by plinthite with low water and nutrient retention capacity. Assessment of soil quality indicators and mapping of resources and soil fertility status is essential for planning and development activities.
**Aims:** Soil quality assessment was made by collecting observations on physical, chemical and biological indicators, soil quality index was computed and generated maps using GIS.
**Study design:** Survey, collection of soil samples and principal component analysis.
**Place and Duration of Study:** A study was conducted in agroecological unit 9 (south central laterites) in Alappuzha district of Kerala during 2020.
**Methods:** Geo-referenced composite soil samples were collected from 75 locations of AEU9 in Alappuzha district, and were characterized for physical, chemical and biological attributes for evaluating soil quality. Principal component analysis (PCA) was carried out for soil parameters and a minimum data set (MDS) was arrived from seven principal components (PC 1 to PC 7) with eigen values greater than 1. The selected soil quality indicators were categorized into classes, assigned with scores and soil quality index was computed. Based on soil quality index, soils were rated as poor, medium or good. GIS based thematic maps of soil quality indicators and index were prepared.
**Results:** The soils of AEU 9 are sandy loam in texture, strongly acidic (pH 4.5-5.5), medium in organic carbon, low in available N, medium in available P and K, deficient in available Ca, Mg and B. Majority (80%) of the soils are rated poor and 20% rated medium in soil quality. From the study it is concluded that pH, clay%, bulk density, available nutrients N, P, K, Ca and S are the key indicators of soil quality in AEU 9.



*Keywords: Agroecological unit; south central laterites; soil quality index; GIS mapping*

## 1. INTRODUCTION

"Soil is the most important natural resource which would support life on this planet through supply of essential nutrients and act as a medium for plant growth. Soil quality, like air or water quality, has an impact on the environment's health and production. Soil quality, often known as soil health, refers to a soil's ability to function within natural or managed ecosystem bounds, to sustain plant and animal productivity, to maintain or improve water and air quality, and to support human health and habitation" [1]. Soil quality declines due to depletion of soil organic matter, nutrient losses from runoff and leaching, desertification, accumulation of toxic substances, excessive use of chemical fertilizers and pesticide, crusting, compaction, improper waste disposal etc.

The agroecological unit is a land unit delineated based on climate variability, landform and soils and/or land cover and having a specific range of potentials and constraints for land use. Assessing soil quality indicators at agroecological unit level by characterization and mapping of existing site specific information would provide precise and scientific catalogue of soils, nature of soil and distribution so that prediction could be made about characters and land potentialities. Soil quality assessment includes a variety of sensitive physical, chemical, and biological characteristics that represent the soil's current functioning status.

"Soil quality evaluation gives an opportunity to redesign land and soil management systems for improved agricultural productivity by providing a framework for assessing the sustainability of various land use regimes. In agriculture, technologies such as remote sensing (RS), geographic information systems (GIS), and global positioning systems aid in the collection of data on agricultural operations, such as land-use/land-cover, weather conditions, soil conditions and other factors that are critical for site characterization and help in determining soil quality and land suitability for farming" [2]. "Arriving at proper soil quality index (SQI) can help to determine the degraded soil properties and help in proper interpretation of soil resources for growing crops, apart from developing fertilizer recommendations" [3].

"The south central laterite, agroecological unit 9 is delineated to represent mid land laterite terrain with typical laterite soils, which are strongly acidic. Lateritic clay soils herein are gravelly and often underlain by Plinthite with low water and nutrient retention capacity. The lowlands have strongly acid, low activity, non-gravelly clay soils with impeded drainage conditions. Mono cropped rubber and coconut intercropped to a variety of annual and perennial crops is the major land use on uplands and rice, tapioca, banana and vegetables on lowlands" [4]. These soils are very strongly acid to slightly acid with overall pH ranging from 4.5 to 5.5, poor in N, P and K, low in bases and also deficient in calcium, magnesium and boron. Therefore, a sustainable management system for improving fertility and productivity of these soils needs to be developed. Plant nutrition needs to be looked into and location and crop specific management practices should be recommended. In this context, the present study was carried out with an objective to make assessment of soil physical, chemical and biological parameters for developing suitable SQI for assessing soils for improving crop production.

## 2. MATERIAL AND METHODS

### 2.1 Study area

A study was conducted in agroecological unit 9 (south central laterites) in Alappuzha district of Kerala to assess the soil quality indicators, to work out SQI and to generate thematic maps using GIS. "The study area lies between 9° 23' 38.28'' and 9°33'63.71'' N latitude, 76°57'88.39'' and 76°65'02.00'' E longitude, which spread over the eastern part of Chengannur block which includes Mulakkuzha, Ala, Cheriyanad and Venmony Panchayaths and Chengannur municipality. It extends over 8058 ha (5.71%) of total area of the district. The south central laterites (AEU 9) represents midland laterite terrain with typical laterite soils and short dry period. The climate is tropical humid monsoon type with mean annual temperature26.5ºC and rainfall 2,827 mm" [5].

### 2.2 Survey and collection of soil sample

A survey was conducted in the study area to identify locations for the collection of soil samples. Georeferenced surface (0-20 cm) soil samples were collected from seventy five sites (Fig.1) in Mulakuzha, Ala, Cheriyanad, Venmony panchayats and Chengannur municipality of AEU9. With the help of GPS, geographical coordinates of each sample site was recorded and used for GIS mapping. The soil samples were shade dried, powdered with wooden pestle and mortar, sieved through a 2mm sieve and stored in labeled plastic containers for analysis.

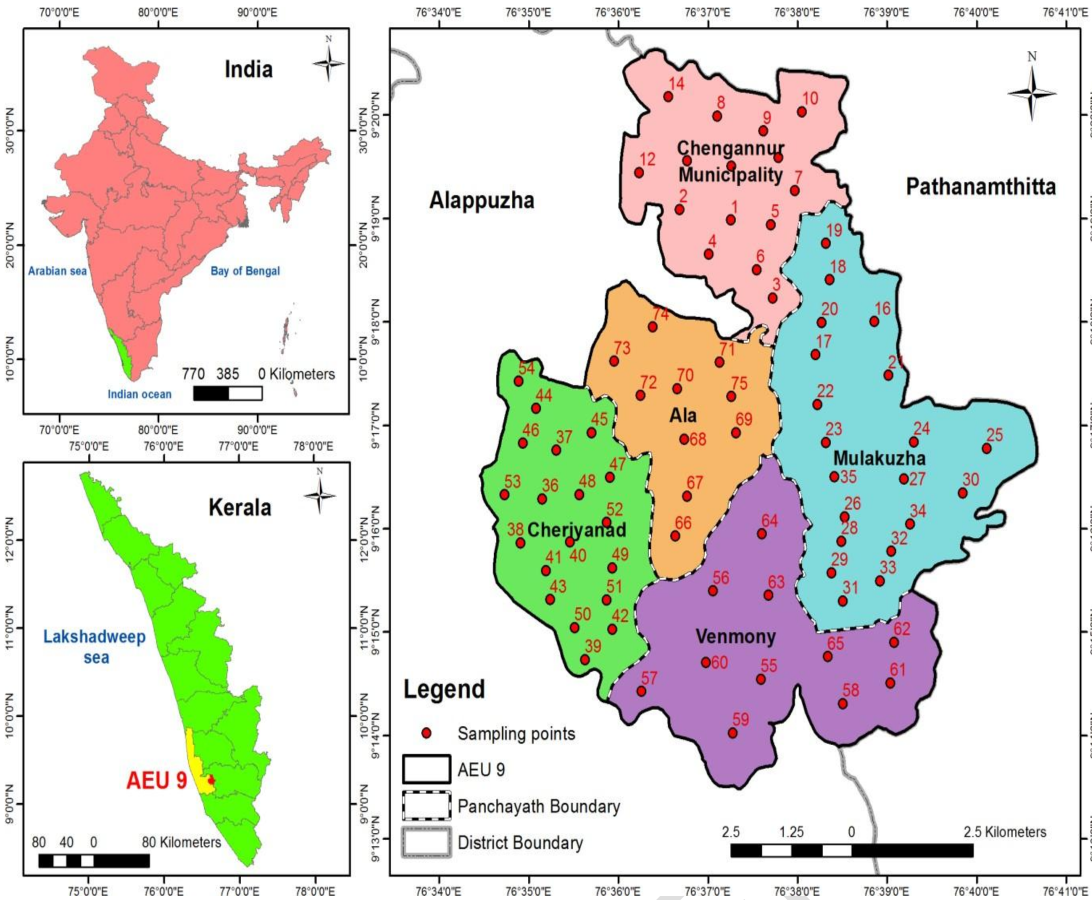


**Fig. 1. Location map of study area and soil sampling sites in AEU9 of Alappuzha district**

## 2.3 Characterization of soil

Soil samples collected from AEU9 were characterized for physical, chemical and biological indicators of soil quality using standard procedures. Soil texture was analyzed by Bouyoucos hydrometer method, bulk density and water holding capacity by core method, water stable aggregates by Yoder's method, pH (soil - water ratio of 1:2.5) using pH meter , organic carbon by wet oxidation method , available nitrogen by alkaline permanganate method , available phosphorus by colorimetric method , available potassium by neutral normal ammonium acetate extraction followed by flame photometry method, available calcium and magnesium by versenate titration method, available boron by azomethane H reagent method, available sulphur by $CaCl_2$ extraction followed by spectroscopy. Biological analysis of dehydrogenase activity was determined by colorimetric method.

## 2.4 Principal component analysis for assessment of soil quality

To assess SQI, 22 soil parameters were considered and tested for significance based on the PC analysis as described by [6], using SPSS software. The PCs which had eigen values of more than one [7] and explained more than 5% variation in data and mainly high factor loaded variables with magnitude of more than0.70 were considered. Within each PC, only highly weighted factors having absolute loading values of more than 0.60 were considered for minimum dataset (MDS). The variables qualified under these series of steps were termed as 'key indicators' and considered for deriving SQI after suitable transformation and scoring.

All observations of each identified key MDS indicators were transformed using linear scoring technique. To assign scores indicators were arranged in the order depending on whether a higher value was considered "good" or "bad" in terms of soil function.

After transformation using linear scoring, MDS indicators for each observation were weighted using PC analysis results. Each PC explained certain amount of variation (%) in the total data set. This variation when divided by total variation explained by all PCs with eigen vectors more than 1, gave weighted factors for indicators chosen under given PC. After performing these steps, to obtain SQI, weighted MDS indicator scores for each observation were summed up using the function. $SQI = \sum_{i=1}^{n}(W_i \times S_i)$

In this relation, Si is the score for the subscripted variable and Wi is the weighing factor obtained from PC analysis. The assumption is that, higher index scores indicated better soil quality or greater performance of soil function. For better understanding and relative comparison, SQI values were reduced to a scale of 0-1 by dividing SQI values with highest SQI value. The numerical values thus obtained, reflect the relative performance of soils, and hence were termed as 'Relative soil quality index' (RSQI). Mean scoring values of MDS were then expressed in percentage to explain their respective contribution to the SQI. RSQI of each sampling location was classified as poor (RSQI< 50%), medium (RSQI 50%-70%) and good (RSQI >70%) [8].

## 2.5 Generation of maps using Geographic Information System

GIS based thematic maps on soil quality indicators and index were prepared to depict the spatial variability using ArcGIS 10.5.1 software following Inverse Distance Weighting (IDW) method, a spatial analyst tool in ArcGIS software. The soil analysis data was loaded into MS Excel, converted to a CSV (Commade limited) file, then imported into the Arc GIS mapping software. The mapping software also imported a shape file containing the boundaries of sampled area. From the spatial analyst tool, IDW was chosen. In the IDW dialogue box, longitude, latitude, and soil attribute values were selected as x, y, and z, respectively, and the processing extent was set to the boundaries of the sampled area. The data was interpolated once the number of sampling points was entered. The resultant map for each parameter was manually categorized using conventional ratings, with distinct colours assigned to each class.

## 3. RESULTS AND DISCUSSION

The efficiency of soils to supply nutrients for crop growth, apart from maintenance of soil physical conditions to optimize yield is one of the important components of soil fertility or quality that would determine the productivity of agricultural system. Hence, the results of physical, chemical and biological indicators of soil quality based on 75 surface samples taken from AEU 9 are described, SQI is calculated and GIS maps are prepared.

### 3.1 Soil quality indicators

### 3.1.1 Physical attributes of soil quality

Bulk density of soil varied between1.33 and 1.60 Mg $m^{-3}$ with a mean value of 1.41 Mg $m^{-3}$(Table 1). Low bulk density (1.33Mg $m^{-3}$) was observed in soils of Chengannur where sediment deposit of clay was noticed resulting in higher organic carbon content (2.41%) and clay content (53.2%), while high bulk density was observed in soils with more sand content. Low bulk density might be due to the influence of organic matter content which improved the aggregation of soil particles. Porosity varied from 44.1 to 78.1 percent in the study area. The high organic carbon content (1.42%) observed in these soils might have favoured soil aggregation and enhancing soil porosity [9]. Clay content varied between 5.62 and 80.20 %, silt between 11.10 and 57.80 % and sand between 9.91 and 79.90 %. Sandy loam was the predominant textural class observed in 58.6% of soils in AEU 9 of Alappuzha district (Fig.2).

**Table1. Physical indicators of soil quality in AEU 9**

| Location | Sand (%) | Silt (%) | Clay (%) | Bulk density (Mg $m^{-3}$) | Porosity (%) | Water holding capacity (%) | Water stable aggregates (%) |
|---|---|---|---|---|---|---|---|
| Chengannur | 26.2 | 38.1 | 53.2 | 1.33 | 60.6 | 55.1 | 55.6 |
| Mulakuzha | 55.6 | 38.2 | 27.3 | 1.35 | 61.9 | 51.3 | 50.8 |
| Cheriyanad | 67.1 | 22.1 | 16.8 | 1.47 | 65.4 | 43.5 | 48.6 |
| Venmony | 59.2 | 31.2 | 12.2 | 1.60 | 71.6 | 39.3 | 46.3 |
| Ala | 55.9 | 30.8 | 23.3 | 1.43 | 64.9 | 46.8 | 48.2 |
| AEU9 | 53.1 | 32.3 | 27.0 | 1.41 | 65.0 | 47.7 | 50.1 |

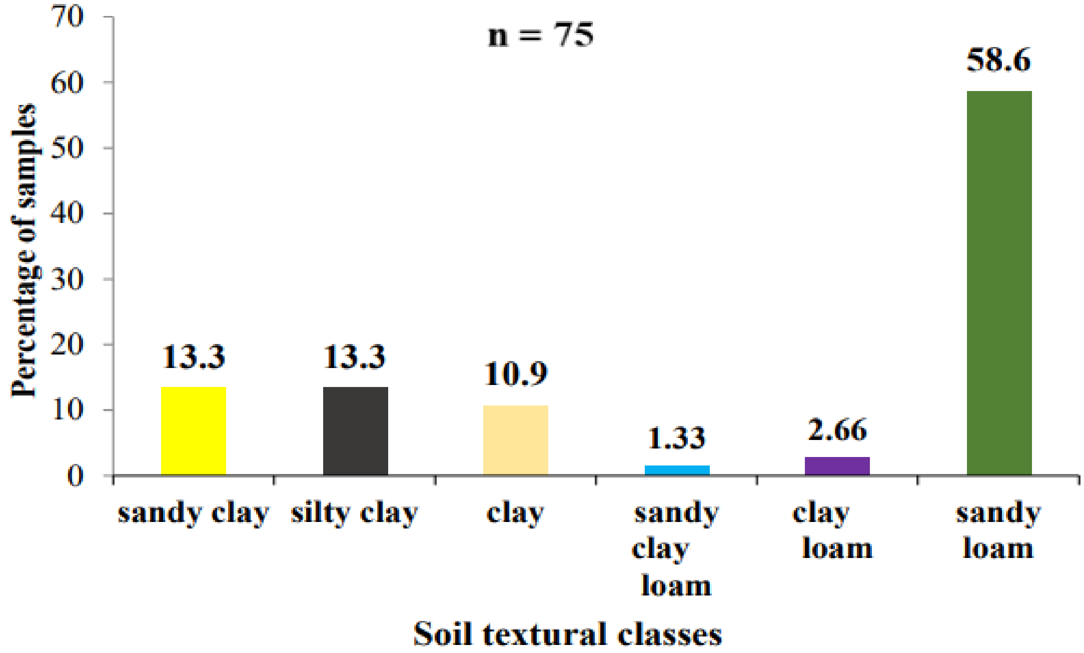


**Fig. 2. Frequency distribution of textural classes in AEU 9 of Alappuzha district**



Water holding capacity was found to be the highest in Chengannur soils where high clayey content was observed and soil texture was silty clay.

Soil aggregation and aggregate stability are the most important soil quality indicators that are affected by texture and organic matter. Water stable aggregates in soil varied between 37.3 and 70.6 %. Water stable aggregates are high in soils rich in organic carbon and clay content. This is attributed to the stabilization of aggregates through the binding action of increased clay and organic carbon content in soils [10].

### 3.1.2 Chemical attributes of soil quality

The present investigation (Fig.3) revealed that soil pH varied from 4.10 to 6.90 with a mean value of 5.02. [11] indicated that the soils of Kerala were mostly laterites and basically acidic in reaction. Majority of soils (90.3%) were in the extremely acidic to strongly acidic category. Leaching of basic cations from the soil might have led to increased acidity. Soil acidity was observed to be lower in areas with sediment deposits where concentrations of basic cations like K and Ca were observed to be higher.

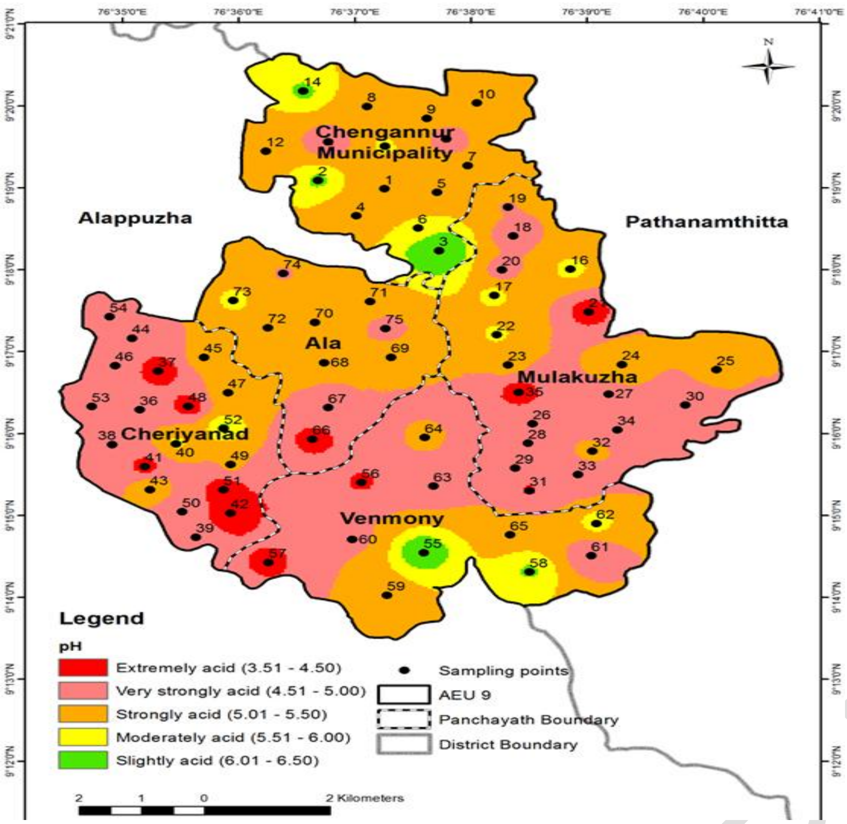


**Fig. 3: Spatial distribution of soil pH in AEU 9 of Alappuzha district**

The available nitrogen content of soil varied between 100 and 627 kg ha$^{-1}$ with a mean value of197kgha$^{-1}$(Table 2). Available nitrogen was low in 89.3% of the soils and only 10.7% were in the medium range. Available nitrogen was found to be medium in some areas of Mulakuzha, Ala and Cheriyanad panchayats and low in other areas. Even with medium to high organic carbon status of the soils under study, the low available nitrogen observed may be attributed to the low mineralization of organic matter in the extremely acidic environment, leaching of nitrate nitrogen due to heavy rainfall experienced in the region and due to losses of nitrogen under anaerobic conditions through nitrate reduction and denitrification [12].

The available phosphorous content of soil varied from 8.32 to 47.8 kg ha$^{-1}$ and was found to be medium in 60% of the soils and high in 26.7% soil indicating a buildup of phosphorus in soil from high levels of phosphorus fertilization and through deposition of phosphates from the sea water. Deficient levels of phosphorus (<10 kg ha$^{-1}$) were observed in 13.3 % of samples. The increased soil acidity adversely affects phosphorus availability and the presence of clay and organic matter deposition in soil contributes to phosphate sorption and reduction in phosphorous availability.

The available K content in soil ranged between 100 and 492 kg ha$^{-1}$. Majority (53.1%) of the soils were medium in available K, 44.6% were high and 2.3% low. Low activity clays such as kaolinite and iron and aluminium oxides and hydroxides are predominant in laterite soils. Hence it may be inferred that the low activity clay minerals in these soils were efficient in holding the exchangeable potassium to a considerable extent which might have contributed to increased availability of potassium [13].

**Table 2. Chemical indicators of soil quality in AEU 9**

| Location | Available nitrogen (kg ha$^{-1}$) | Available phosphorus (kg ha$^{-1}$) | Available potassium (kg ha$^{-1}$) | Available calcium (mg kg$^{-1}$) | Available magnesium (mg kg$^{-1}$) | Available sulphur (mg kg$^{-1}$) | Available boron (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| Chengannur | 156 | 16.2 | 177 | 327 | 64.5 | 5.71 | 0.31 |
| Mulakuzha | 233 | 19.2 | 299 | 259 | 69.4 | 11.4 | 0.12 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cheriyanad | 183 | 13.1 | 280 | 189 | 71.0 | 10.5 | 0.11 |
| Venmony | 189 | 10.2 | 219 | 189 | 129 | 17.9 | 0.20 |
| Ala | 219 | 12.3 | 254 | 221 | 59.7 | 10.2 | 0.13 |
| AEU 9 | 197 | 14.8 | 252 | 239 | 76.4 | 10.8 | 0.10 |

The deficiency of calcium and magnesium is severe in the soils of the study area. The 64 % of samples were deficient in plant available calcium (<300 mg $kg^{-1}$) and all the samples were deficient in plant available magnesium (<120 mg $kg^{-1}$). The high rainfall in this region facilitate the leaching of basic cations calcium and magnesium from soil resulting in their concentration below the sufficiency range as also reported by [14]. Available sulphur content in soil varied between 3.02 and 27.5 $mgkg^{-1}$and was found to be adequate in 93.3% of soils. The higher levels of available sulphur might be due to the accumulation of organic matter and sediments in these soils.

Available boron in soil ranged between 0.01 and 0.41 $mgkg^{-1}$. Available B was deficient in all the soils of AEU 9. This can be attributed to the higher mobility of boron in soils and also leaching losses which led to B deficiency in these soils. High intensity rainfall will lead to loss of soluble forms of boron by leaching [15].

### 3.1.3 Biological attributes of soil quality

Organic carbon content ranged between 0.51 and 2.62% with a mean value of1.42%. Majority (61.3%) of the soils are having medium organic carbon status followed by 38.7% soils with high status (Fig.4). Organic carbon was high in most of the areas in Chengannur and Mulakuzha and medium in other panchayats. This can be attributed to the deposition of sediments rich in organic matter in compliance with the findings of [16].




**Fig. 4: Spatial distribution of organic carbon in AEU 9 of Alappuzha district**

Dehydrogenase activity in soil varied between13.1and27.3 µgTPF hydrolysed $g^{-1}$soil $24hr^{-1}$in AEU 9. Majority (64%) of soils registered dehydrogenase activity between 25and 50 µg PNP produced g $soil^{-1}$ $h^{-1}$ (Fig. 5). Increased dehydrogenase activity indicated a shift in micro flora from aerobic to anaerobic [17].

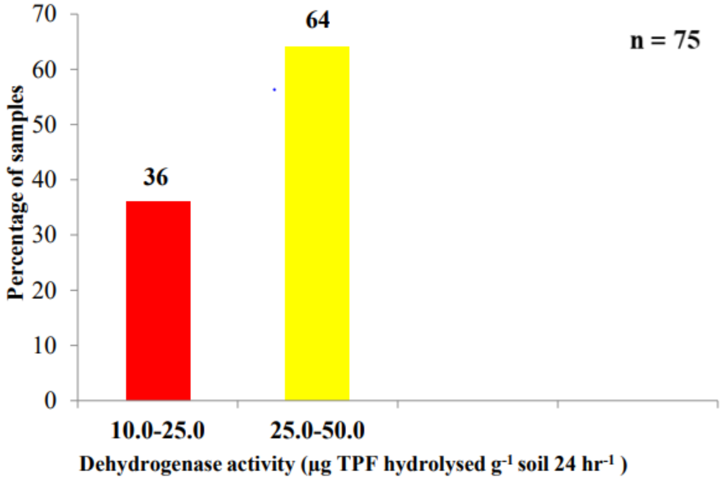


**Fig. 5. Frequency distribution of dehydrogenase activity in AEU 9**

### 3. 2 Soil quality index

The soils of total cultivable areas of AEU 9 were assessed for soil quality in which PC analysis was performed for 22 variables. In the PC analysis of variables, about 67.2% of variance in soil physical, chemical and biological parameters was explained by 7 PCs with eigen values 'greater than1' (Table 3).

**Table 3. Principal component analysis (PCA) of soil quality parameters**

| **Particulars** | **PC1** | **PC2** | **PC3** | **PC4** | **PC5** | **PC6** | **PC7** |
|---|---|---|---|---|---|---|---|
| **Eigen value** | 3.987 | 1.909 | 1.5 | 1.309 | 1.226 | 1.14 | 1.048 |
| %variance | 22.1 | 10.6 | 8.3 | 7.3 | 6.8 | 6.3 | 5.8 |
| Cumulative variance | 22.1 | 32.8 | 41.1 | 48.4 | 55.2 | 61.5 | 67.3 |
| **Eigen vectors/ Variables** | **Loading of variables on PCs** | | | | | | |
| Particle density ($Mgm^{-3}$) | -0.084 | -0.136 | 0.117 | 0.149 | 0.211 | 0.202 | 0.117 |
| Bulk density ($Mgm^{-3}$) | 0.084 | -0.106 | 0.183 | 0.179 | **0.522*** | **0.44*** | -0.310 |
| Soil moisture content (%) | -0.106 | -0.143 | 0.458 | -0.378 | -0.204 | 0.018 | -0.028 |
| Water holding capacity (%) | -0.195 | -0.338 | 0.438 | -0.129 | 0.004 | -0.103 | 0.113 |
| Mean weight diameter (mm) | -0.286 | -0.209 | -0.062 | -0.225 | -0.138 | -0.026 | 0.022 |
| Water stable aggregates (%) | 0.158 | 0.295 | -0.078 | -0.179 | 0.322 | 0.371 | -0.024 |
| Sand (%) | 0.283 | -0.099 | 0.036 | 0.321 | -0.072 | -0.08 | 0.085 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Silt (%) | 0.178 | 0.193 | 0.291 | 0.249 | 0.124 | -0.205 | 0.217 |
| Clay (%) | **-0.404*** | -0.341 | -0.201 | 0.056 | 0.26 | 0.052 | -0.184 |
| EC ($dSm^{-1}$) | 0.2875 | 0.09 | -0.096 | -0.106 | -0.031 | 0.236 | 0.161 |
| pH | -0.041 | -0.093 | -0.144 | -0.306 | -0.171 | -0.145 | **-0.573*** |
| OC% | 0.132 | -0.057 | -0.069 | -0.245 | 0.161 | 0.113 | 0.232 |
| N($kgha^{-1}$) | -0.131 | -0.212 | **0.513*** | 0.224 | -0.189 | 0.374 | -0.196 |
| P($kgha^{-1}$) | 0.242 | **-0.364*** | 0.101 | -0.112 | 0.174 | -0.074 | 0.071 |
| K($kgha^{-1}$) | -0.22 | **0.398*** | 0.092 | 0.031 | 0.03 | -0.371 | 0.444 |
| Ca($mgkg^{-1}$) | -0.195 | -0.182 | 0.179 | **-0.518*** | -0.056 | -0.122 | -0.197 |
| Mg($mgkg^{-1}$) | 0.148 | 0.295 | 0.197 | -0.074 | 0.106 | 0.352 | 0.277 |
| S($mgkg^{-1}$) | -0.042 | -0.047 | 0.067 | 0.046 | **0.497*** | 0.034 | 0.045 |
| B($mgkg^{-1}$) | 0.034 | 0.046 | 0.0876 | 0.062 | --0.067 | 0.035 | 0.034 |
| Ex. Acidity | 0.132 | -0.324 | -0.069 | -0.245 | 0.161 | -0.113 | -0.232 |
| Acid phosphatase | -0.131 | -0.318 | -0.144 | 0.224 | 0.189 | 0.374 | 0.196 |
| Dehydrogenase | 0.242 | -0.057 | 0.101 | -0.438 | 0.174 | -0.074 | 0.071 |

**Parameters used in MDS*

The eigen values ranged from 1.048 (PC7) to 3.987 (PC1) with variance in the range of 5.8% (PC7) to 22.1% (PC1). Highly weighted variables which are loaded onPC1included clay content followed by available P and K, available N, exchangeable Ca, bulk density and available S, bulk density and soil pH were highly loaded variables on PC2PC3, PC4, PC5, PC6 and PC7 components respectively (Table 4).

**Table 4. Minimum data set (MDS) for the assessment of soil quality in AEU 9**

| PC1 | PC2 | PC3 | PC4 | PC5 | PC6 | PC7 |
|---|---|---|---|---|---|---|
| Clay percent | Available P<br>Available K | Available N | Available Ca | Bulk density<br>Available S | Bulk density | pH |

To formulate the soil quality index, the parameters in the MDS were assigned appropriate weights and each class with suitable scores [18]. Scoring was done following the method suggested by [8] and [19] with slight modifications based on soil fertility ratings for Kerala soils. Available N and P were assigned with the highest weightage of 20 each followed by bulk density, texture, pH, available K, Ca and S with weightage of 10 each and categorized into four classes with scores ranging from 4 to 1. After scoring of soil quality indicators, a weighted SQI was computed. A relative soil quality index was also computed to study the change in soil quality and samples were rated based on RSQI value. Soil quality index (SQI) of soils in AEU 9 ranged from 120 to 250 with a mean value of 174 (Table 5).

**Table 5. Soil quality index (SQI) and relative SQI (RSQI) of soils of AEU 9**

| **Location** | **SQI** | | **RSQI (%)** | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Chengannur | 130 - 225 | 180 ± 28.6 | 40.0 - 55.0 | 44.8 ± 6.79 |
| Mulakuzha | 150 - 250 | 195 ± 35.7 | 36.3 - 62.5 | 48.8 ± 8.81 |

| | | | | |
|---|---|---|---|---|
| Cheriyanad | 135 - 220 | 168 ± 26.3 | 33.8 - 55.0 | 45.7 ± 6.60 |
| Venmony | 130 - 170 | 149 ± 17.2 | 32.5 - 42.5 | 37.0 ± 4.20 |
| Ala | 120 - 185 | 165 ± 25.1 | 35.0 - 48.8 | 41.3 ± 6.29 |
| AEU9 | 120 - 250 | 174.± 31.5 | 32.5 - 62.5 | 43.6 ± 7.87 |

The relative soil quality index (RSQI) ranged from 32.5 to 62.5 %with a mean of 43.6% (Table 5). The highest mean value of relative soil quality index was observed in Mulakuzha (48.8%) followed by Cheriyanad (45.7%) and Chengannur (44.8%) and the lowest in Venmony (37%). Majority of the soils (80%) had poor soil quality while 20 %of soils had medium soil quality (Fig.6). Soil quality was observed to be maximum in Chengannur and Mulakuzha where organic carbon, available nitrogen, phosphorous, potassium and calcium were found to be high and sediment depositions of clay and silt were observed.

The low to medium soil quality of AEU 9 may be attributed to the inherent properties of laterite soils, type of vegetation and micro climate as reported by [13] . . Clay percent in soil emerged as a key soil quality indicator based on the study, which plays a key role directly or indirectly in influencing quality of these soils because majority of soils of AEU 9 are sandy loam in texture. Among the nutrients, P and K, followed by N, Ca, S and other parameters bulk density and pH also emerged as key soil quality indicators. This might be due to the reason that these soils are strongly acidic (low pH), having high bulk density, low in N, medium in P and K, deficient in Ca. The results outline the need for regular liming to control soil acidity and to alleviate Ca deficiency and addition of organic matter and recommended dose of N, P and K fertilizers to improve nutrient status and to sustain agricultural systems as well as to maintain soil quality.

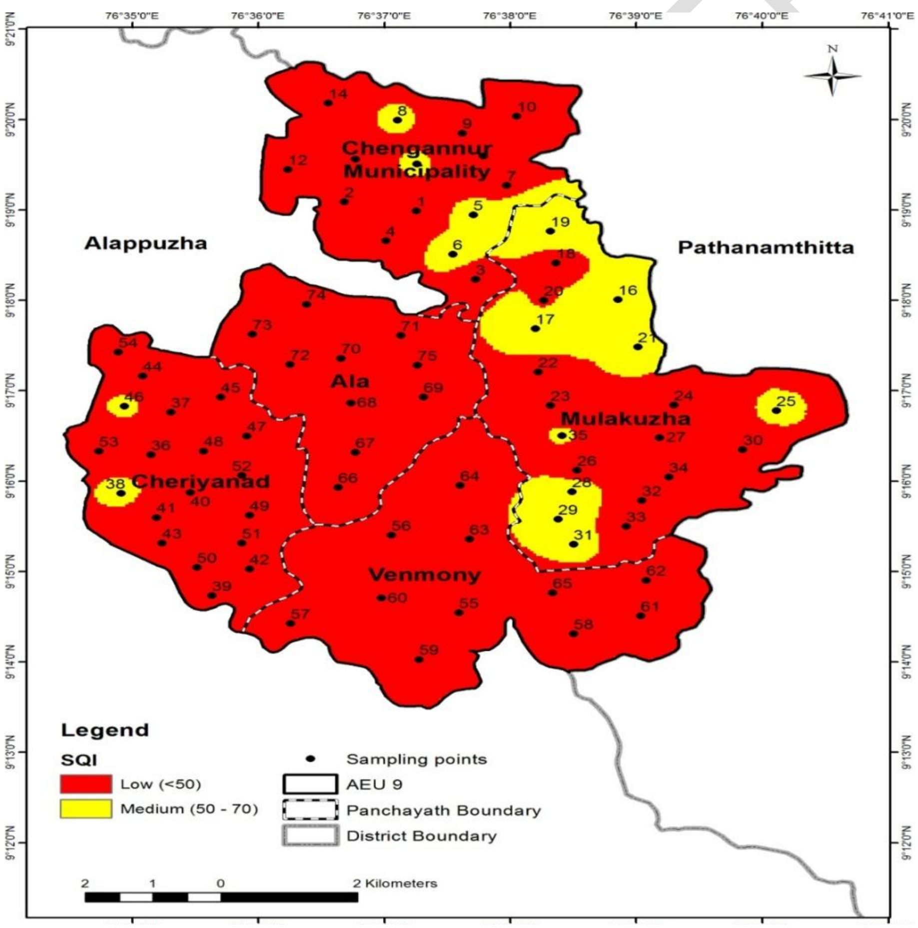


**Fig. 6. Spatial distribution of SQI in soils of AEU 9 in Alappuzha district**

## 4. CONCLUSION

Assessing soil quality by examining the variability existing in soil parameters clearly showed that farmers can cultivate crops whose nutrient requirements are more in the areas where SQI was highest. On other hand crops which require less nutrients can be grown in areas where SQI was lowest. Examining relationships of parameters, and analyzing principal component indicated that eight parameters have significantly contributed to the SQI. Soil pH, clay %, bulk density, nutrients N, P, K, Ca and S are the important key indicators of soil quality.

The soil quality can be enhanced by managing the soil pH and increasing the soil aggregation using organic amendments and Ca containing fertilizers in low SQI areas. Application of good quality and more amount of locally available organic matter to the areas with low SQI would improve the soil quality and maintain sustainable farming as it increases the OC, available content and micronutrients in soil.

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