Soil quality assessment of selected panchayaths of *Typic Ustipsamments* of Kerala, India

ABSTRACT

Aims: Assessment of soil quality of selected panchayaths of sandy plains (*Typic Ustipsamments*) of Kerala based on various soil attributes and to work out soil quality index (SQI).

Study design: A Survey was conducted in the selected panchayaths of sandy plains of Kerala (AEU 3) and 100 representative georeferenced surface soil samples were collected from various land uses. These soil samples were characterized for important physical, chemical and biological properties.

Place and Duration of Study: Onattukara Regional Agricultural Research Station, Kayamkulam between April 2021 and May 2022.

Methodology: Hundred geo-referenced surface soil samples were collected from various land uses of selected panchayaths of sandy plains of Kerala and characterized for various physical (texture, bulk density, particle density, porosity, aggregate analysis, soil moisture and WHC), chemical (pH, EC, organic carbon and available macro and micronutrients and biological attributes (acid phosphatase and dehydrogenase activity). Principal component analysis was used to set up the minimum data set of the indicators to compute the soil quality index. Seven principal components were extracted from which nine indicators that highly influenced the soil quality were identified. Scores and weights were assigned to each indicator, and they were aggregated to compute the soil quality index. The relative soil quality index of the soils was also found.

Results: Increased soil acidity and low levels of nutrients like nitrogen, potassium, magnesium, sulphur, and boron were noticed in these soils. Available P content of the soil was high. Mg, S, and B were deficient in 100 per cent of the samples, whereas, Fe and Mn remained sufficient. Ca,Zn and Cu exhibited 72.9, 24.3 and 21.7 per cent deficiency, respectively. Majority of the soils belonged to medium soil quality (78.6 per cent), followed by poor (12.8 per cent) and good (8.6 per cent) quality.

Conclusion: Majority of soils of selected panchayaths of sandy plains of Kerala fell into the medium soil quality class. But there are several soil fertility issues in these soils. Hence site specific and crop specific management strategies have to be followed for the profitable cultivation of the crops and soil test-based fertilizer application has to be followed. It is mandatory to maintain the fertility of the soil for the sustainability of the environment.

Keywords: [Sandy plain, soil quality, PCA, SQI, RSQI, Typic Ustipsamments]

1. INTRODUCTION

Soil quality is an assessment of the present functioning capacity of the soil and how well it will be preserved for future use. As soil quality cannot be measured directly, it must be inferred from measuring changes in attributes of the ecosystem, referred to as indicators. Measurable soil attributes that influence the capacity of soil to perform crop production or environmental functions are referred as the soil quality indicators [1]. Identifying key soil attributes that are sensitive to soil functions allows the establishment of minimum data sets (MDS). Such data sets are composed of a minimum number of soil properties that will provide a practical assessment of one or several soil processes of importance for a specific soil function [2]. Use of MDS reduces the need for determining a large number of indicators to assess soil quality [3].

Key attributes of soil quality include different physical, chemical and biological properties which interact in complex ways to determine its potential fitness or capacity to produce healthy and nutritious crops [4].Decline of soil quality is crucial in land degradation [5]. Soil quality indicators based on a combination of soil properties could better reflect the status of soil quality degradation as compared to individual parameters. Soil quality index (SQI) can reflect the extend of degradation and suggest appropriate remedial measures such as optimal fertilizer rate and suitable land management practices considering potentials and constraints of different fields at large scale. In a state like Kerala with high population density, land is definitely a scarce resource. Moreover, higher than 67 per cent of the total geographic area of the state is subjected to soil degradation due to various factors like erosion, landslides, water logging, acidification, pollution *etc.* This resulted in a higher rate of soil loss, compared to the national average. Soil quality index combine various information effectively and hence is an effective tool for multi-objective decision-making [6]. The sandy plain region of Kerala comprises a unique agro-ecological unit designated as Onattukara sandy plain (AEU 3). The soils of this region exhibit wide spatial variability in their properties. These soils are generally coarse textured with immature profiles and low nutrient and water retention capacity. The ultimate purpose of assessing soil quality is to protect and improve long term agriculture productivity, water quality and habitats of all organisms including human. So the present study was undertaken to assess the soil quality of selected panchayaths of sandy plains of Kerala based on various soil attributes and to work out soil quality index (SQI) which will help to evaluate soil quality, and in turn, help to enhance the environmental sustainability. Soil health test reports developed will allow for an overall assessment, as well as the identification of specific soil constraints and soil quality build up will help in the resilience of degraded soils.

2. MATERIALS AND METHODS

A survey was conducted in seven selected panchayaths representing the sandy plains of Kerala *viz.*, Thazhakkara, Cheruthana, Bharanikkavu, Alappad, Palamel, Muthukulam and Thekkekkara panchayths. The major land uses in these panchayaths were rice, coconut, banana and vegetables. Hundred geo-referenced surface soil samples were collected from these panchayaths and characterized for various physical (texture, bulk density, particle density, porosity, aggregate analysis, soil moisture, and WHC), chemical (pH, EC, organic carbon, available macro and micronutrients) and biological attributes (acid phosphatase and dehydrogenase activity).

Principal component analysis was used to set up the minimum data set of the indicators to compute the soil quality index. Seven principal components were extracted from which nine indicators that highly influenced the soil quality were identified, *viz.* sand per cent, available P, available Ca, available Mg, bulk density, per cent of water stable aggregates, organic carbon, available Zn and available B. Scores and weights were assigned to each indicator, and they were aggregated to compute the soil quality index. The relative soil quality index of the soils was also found. GIS techniques were used to prepare thematic maps of various soil attributes and relative soil quality indices of these panchayaths.

3. RESULTS AND DISCUSSION

3.1 SOIL QUALITY ANALYSIS

The soil samples collected were characterized for important physical, chemical and biological properties to assess the soil quality. **S**oil samples were subjected to analysis of various physical properties like bulk density, particle density, porosity, texture, aggregate analysis, soil moisture content and water holding capacity. Geo referenced soil samples were analysed for the fertility parameters like pH, electrical conductivity, organic carbon, available primary nutrients *viz*. N, P and K, secondary nutrients *viz*. Ca, Mg and S and micronutrients *viz*. Fe, Mn, Cu, Zn and B (Table 1). Acid phosphatase and dehydrogenase activity were also assessed as part of assessing the biological properties of the soil. Depletion of nutrients like nitrogen, potassium, magnesium, sulphur, and boron

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was also noticed in these soils. Mg, S, and B were deficient in 100 percent of the samples, whereas, Fe and Mn remained sufficient. Ca, Zn and Cu exhibited 72.9, 24.3, and 21.7 percent deficiency, respectively.

Table 1. STATUS OF SOIL REACTION AND NUTRIENTS

Parameter	Fertility class	Percent samples
pH	Extremely acidic	37.2
	Very strongly acidic	57.1
	Strongly acidic	5.7
Organic carbon (%)	Low	20
	Medium	50
	High	30
Available N (kg ha^{-1})	Low	71.4
	Medium	28.6
	High	0
Available P (kg ha^{-1})	Low	0
	Medium	28.6
	High	71.4
Available K (kg ha^{-1})	Low	62.9
	Medium	37.1
Available Ca (mg kg^{-1})	Deficient	72.9
	Sufficient	27.1
Available Mg (mg kg^{-1})	Deficient	100
Available S (mg kg^{-1})	Low	100
Available Zn (mg kg^{-1})	Deficient	24.3
	Sufficient	75.7
Available Cu (mg kg^{-1})	Deficient	21.7
	Sufficient	78.3
Available B (mg kg^{-1})	Deficient	100

3.2. FORMULATION OF MINIMUM DATA SET (MDS)

Principal component analysis (PCA) was used for setting up the minimum data set (MDS). The PCA resulted in seven principal components (PCs), which had eigen value more than 1, which was selected for the MDS (Table 2). Only the highly weighted variables (within 10 per cent of the factor loading) with in each PC were retained. When more than one variable was retained in a PC, the correlation between was worked out and if they are significantly correlated (r > 0.6), the one with highest loading factor was retained for the MDS and the rest excluded.

Table 2. Minimum Data Set

PC1	PC2	PC3		PC4	PC5	PC6	PC7
Sand per cent	Available P	Available Mg		Bulk density	Per cent of water stable aggregates	Organic carbon	Available B
	Available Ca					Available Zn	

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3.3.FORMULATION OF SOIL QUALITY INDEX

3.3.1. SCORING OF THE PARAMETERS

In order to formulate the soil quality index of the analysed soil samples, the parameters in the minimum data set was assigned with appropriate weights based on existing soil conditions, cropping patterns, and agro-climatic conditions [7] and each class with proper score according to the procedure by [8], [9] with slight modifications based on the soil fertility ratings for secondary and micronutrients for Kerala soils (table3).

TABLE 3. SCORING OF THE PARAMETERS

SOIL QUALITY INDICATORS	WEIGHTS	CLASS I WITH SCORE 4	CLASS II WITH SCORE 3	CLASS III WITH SCORE 2	CLASS IV WITH SCORE 1
WSA%	15	>90	70 – 90	50 – 70	< 50
B D (Mg m^{-3})	10	1.3 – 1.4	1.2 – 1.3 OR 1.4 – 1.5	1.1 – 1.2 OR 1.5 – 1.6	< 1.1/ > 1.6
TEXTURE (SAND %)	10	LOAM	CLAY LOAM/ SANDY LOAM	SAND/CLAY	GRIT
OC (%)	15	>1	1 – 0.75	0.75 – 0.5	< 0.5
AVAILABLE P (kg ha^{-1})	10	>24	15 – 24	15 – 10	<10
AVAILABLE Ca (kg ha^{-1})	10	>300	300 – 250	250 – 150	<150
AVAILABLE Mg (kg ha^{-1})	10	>120	120 – 90	90 – 60	<60
AVAILABLE Zn (kg ha^{-1})	10	>1.0	1.0 – 0.5	0.5 – 0.25	< 0.25
AVAILABLE B (kg ha^{-1})	10	>0.5	0.5 – 0.25	0.25 – 0.1	<0.1

3.3.2. COMPUTATION OF SOIL QUALITY INDEX AND RELATIVE SOIL QUALITY INDEX.

The soil quality index (SQI) of the soil samples was calculated using the weighted additive method using the equation ,

$SQI = \sum W_i \times M_i$, Where W_i is weight of the indicators and M_i is the marks of the indicator classes.

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Relative soil quality index (RSQI) of the samples was calculated to study the change in soil quality of the samples (table 4) . The soil quality index of the samples varied between 176 and 294, with a mean value of 239. Mean value of SQI was found to be maximum (259) in the Palamel panchayath and minimum (218) in the Alappad panchayath. The relative soil quality index of the samples ranged from 43.6 per cent to 78.7 per cent. The Palamel panchayath was observed to have the highest mean RSQI (64.6 percent) and Alapapd was observed to have the lowest value (50.1 per cent) .

The soils were categorized into poor, medium and good based on the relative soil quality index. Majority of the samples (78.6 per cent) fell in the medium class and 12.8 per cent into the low class of soil quality. Only 8.6 per cent of the samples were regarded as good quality soil (Fig. 1).

TABLE 4. SQI AND RSQI OF VARIOUS PANCHAYATHS

PARAMETERS→	SOIL QUALITY INDEX (SQI)		RELATIVE SOIL QUALITY INDEX (%) (RSQI)	
PANCHAYATH↓	MEAN ± SD	RANGE	MEAN ± SD	RANGE
THAZHAKKARA	250 ± 29.1	205 – 295	62.5 ± 7.26	52.5 - 73.8
CHERUTHANA	240 ± 18.6	215 – 275	60.0 ± 4.64	53.8 - 68.8
BHARANIKKAVU	241 ± 23.1	200 - 270	60.3 ± 5.77	50.0 - 67.5
ALAPPAD	218 ± 39.9	170 - 295	50.1 ± 9.98	42.5 - 73.8
PALAMEL	259 ± 34.4	195 - 305	64.6 ± 8.59	48.8 - 76.3
MUTHUKULAM	256 ± 25.5	230 - 320	63.9 ± 6.39	57.5 - 80.0
THEKKEKKARA	220 ± 24.2	190 - 255	55.0 ± 6.04	47.5 - 63.8
AEU 3	239 ± 31.5	176 - 294	59.7 ± 7.87	43.6 - 78.7

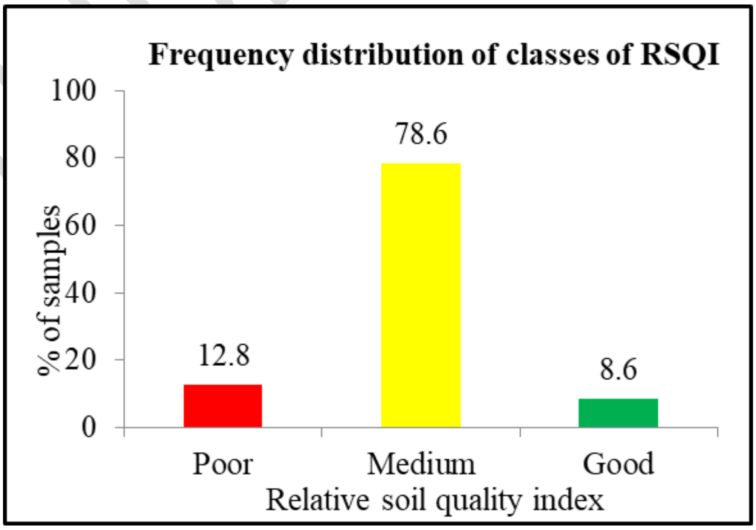

Fig.1. Frequency distribution of classes of RSQI in the sandy plain

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4. CONCLUSION

The majority of the soils of selected panchayaths of sandy plains of Kerala fell into the medium soil quality class. However, there are several soil fertility issues in these soils. Soil acidity is a major problem in this region which demands the application of adequate liming materials. Addition of more organic inputs can minimise the physical constraints of Onattukara soils.Split application of N and K fertilizers can reduce the leaching losses.Dose of P fertilizer has to be modified in the light of high P status in the AEU. Monitoring of secondary and micronutrients on regular basis is also required. Site specific nutrient management is required to restore the soil health in these soils. Hence site-specific and crop specific nutrient management strategies have to be followed for the profitable cultivation of the crops and soil test-based fertilizer application has to be followed. It is mandatory to maintain the fertility of the soil for the sustainability of the environment.

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