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Soil quality assessment of different villages of Chikkamagalur block in Chikkamagalur district of Karnataka (India)

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Abstract
Soil is a vital natural resource which supports the life on earth. Among several factors which influence the crop production potential, soil fertility is the fundamental factor. An attempt is made to assess the physico-chemical characteristics of different villages in Chikkamagalur block of Chikkamagalur district of Karnataka using various soil quality parameters. Accordingly it is found that the soils of the Chikkamagalur block were low in the available nitrogen and sulphur with the mean values of 163.95 kg ha^{-1}, medium in available phosphorus contents with the mean value of 17.06 kg ha^{-1} and high in potassium contents of soil with mean value of 483.39 kg ha^{-1}. The soils were found to be acidic to neutral in reaction with the average pH value of 5.71. The soils were free from salinity hazards since the mean value of electrical conductivity was found to be 0.18 dSm^{-1}. The organic carbon statuses of soils were found medium to high with mean of 0.93%. The available calcium, magnesium and Sulphur are found sufficiently with 1.72 me/100g, 2.70 me/100g and 0.50 mg kg^{-1} respectively. The soil is deteriorating in its quality and is mainly due to the continuous cropping. So it is recommended for the study area that sustainable cropping management systems are adopted to conserve and improve the soil quality.

Keywords: Soil fertility, soil quality, salinity, acidic, neutral and sustainable cropping

Introduction
Soil is a vital natural resource which supports life on earth which plays very important role in the production of food and maintains the socio-ecological balance. Among several factors which influence the crop production potential, soil fertility is the fundamental factor. It is only after meeting the basic needs of air, water and food that we consider about safety and quality of different aspects of life. Soil is one such aspect we need to focus on since it is vital for production of crops. Sustaining soil quality is the most effective method of ensuring sufficient food to support life. Soil quality is defined as the capacity of a specific kind of soil to function within the ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality, and sustain plant, animal and human health (Doran and Parkin, 1994) [4]. The soils in the district are mainly belongs to the order Inceptisols, Entisol, Vertisol and Alfisols. Red sands and red loamy soils are the major soil types. Mixed red and black soils are found in small patches in the hilly areas of the central and north-east parts of the district, respectively. About 50 per cent of the soils mostly from the Malnad or mountainous parts of the district are acidic in nature. The soluble-salt content is generally low. The soils in Malnad areas are well supplied with organic matter and ten per cent of the soils confined to Maidan areas are deficient in organic matter. The phosphorus and potash content are generally poor. The particular nature of these Malnad regions were subjected to cultivation for many years in the study area had led to decline in soil fertility. Therefore, there is special need for the analysis of soil nutrient status of these soils. By keeping above in mind an attempt is made to assess the physico-chemical characteristics of different villages in Chikkamagalur block of Chikkamagalur district of Karnataka using various soil quality parameters.

Materials and methods
Study area: Chikkamagalur is situated in the south-western part of the Karnataka. It is famous for its coffee cultivation and is known as the coffee land of Karnataka. It has a geographical area of 7,22,075 hectares lies between 12° 54' and 13° 53' North latitude, 75° 04' and 76° 21' East longitude. The district comprises seven talukas with Chikkamagalur being the headquarters of the district.Twenty five representative surface soil samples were collected from 4 different villages of Chikkamagalurblock, These villages include Mugtihalli,

Shirgunda, Dambadahalli and Mattavara.These samples were analyzed for different soil parameters.

Analysis of Physico-chemical parameters: Twenty five surface soil samples from each of the identified location from farmers field of different villages of Chikkamagalur block were collected with the help of khurpi to a depth of 0 - 15 cm in the form of 'V' shape. Collected surface soil samples were brought in to laboratory and air dried in room temperature. These soil samples were crushed, powdered and grounded using wooden roller and sieved using 2.0 mm sieve. Finally a representative sample of 1 kg was preserved in a labeled polythene bag for further laboratory analysis. The bulk density and particle density were estimated using pycnometer (Black, 1965) [2]. Porosity was calculated using the bulk density and particle density. Maximum water holding capacity was determined using keen box (Piper, 1966) [11]. The pH of the soil samples were measured using 1:2.5 soil-water suspension by using potentiometer method (Jackson, 1973) [5]. Electrical Conductivity was measured using the same soil-water suspension using EC meter (Jackson, 1973) [5]. The Organic Carbon was determined by using modified wet oxidation method (Walkley and Black, 1934) [19]. Available nitrogen status of the soil samples were measured using alkaline potassium permanganate method (Subbiah and Asija, 1956) [15]. Available phosphorus of the soil samples were actually determined by Olsen's method using 0.5M NaHCO3extractant, colorimetrically using spectrophotometer (Olsen *et al*., 1954) [10]. Available potassium was extracted by using neutral normal ammonium acetate extractant by using flame photometer (Schollenberger and Simon, 1945) [13]. Exchangeable calcium and magnesium contents were extracted by using neutral normal ammonium acetate extractant and content was measured by Versanate titration method (Jackson, 1973) [5]. Available sulphur was extracted by using 0.15% calcium chloride solution followed by turbidity development with barium chloride and estimated for sulphur colorimetrically using spectrophotometer (Chesnin and Yien, 1950) [3].

Results and Discussion

The results of the soil physical properties, macro nutrients and secondary nutrients of different villages are given in the table 1.

Physico-chemical parameters: The pH of the soil samples was found acidic to neutral in reaction and it varies 4.2 to 7.3 with the average value of 5.71. The Electrical Conductivity of the soils ranges from 0.07-0.75 dSm^{-1} with the average value 0.13 dSm^{-1}. This indicates that all the soil samples were free from salt problems based on the limits suggested by Muhr *et al.* (1963) [9]. The bulk density and particle density of the soils ranges from 1.30-1.55 Mg m^{-3} and 2.30-2.69 Mg $m^{-3}$with the mean values of 1.41 Mg $m^{-3}$and 2.52 Mg m^{-3}, respectively. The porosity and water holding capacity of the soils were found from 39.56 to 48.87 % and 26.07 to 40.71% with the mean values of 44.11% and 33.04%, respectively. The organic carbon status of the soil ranges from 0.55 to 1.95% with the mean value of 0.93%. Based on the limits suggested by Ramamurthy *et al.* (1969) [12] only 12% of the soil samples were found medium (0.50-0.75%) in organic carbon status and 88% of the soils of the region are high (>0.75%) in the organic carbon status.

Available macronutrients: The available Nitrogen status of the soils ranges from 72.13-470.40 kg ha^{-1} with the average value of 163.95 kg ha^{-1}. According to ratings suggested by Ramamurthy *et al.* (1969) [12], 88% of the soils were low (<280kg ha^{-1}) in the Nitrogen status and only about 12% of the samples are medium (280-560 kg ha^{-1}) in the fertility status of Nitrogen. The available phosphorus content ranges between 7.72 and 38.63 kg ha^{-1} with the average value of 17.06 kg ha^{-1}. According to the ratings suggested by Muhr *et al.* (1965) [9], 84% of the samples are low (<22.4 kg ha^{-1}) in Phosphorus status and only 16% of the soil samples are medium in phosphorus status. The very low status of phosphorus in soils may be due to the presence of more than 50% of phosphorus stored in organic forms and after decomposition of organic matter as humus is formed which forms complex with Al and Fe and that is a protective cover for P fixation with Al and Fe thus reduce phosphorus adsorption/ Phosphate fixation (Tisdale *et al*., 1997) [17]. The available Potassium status of the soils ranges between 145.60 kg ha^{-1} and 1500.80 kg ha^{-1} with the average value of 483.39 kg ha^{-1}. According to the limits suggested by Muhr *et al.* (1965) [9], 8 % of the samples are low (<168 kg ha^{-1}), 40% of the samples are medium (168-336 kg ha^{-1}) and about 52% of the samples are high (>336 kg ha^{-1}) in the Potassium status of the soil.

Secondary macronutrients: The secondary nutrients of the soil include Calcium, Magnesium and Sulphur ranges from 0.10-4.30 me/100g, 0.80-12.90 me/100g and 0.10-2.99 mg kg^{-1} with the average values of 1.72 me/100g, 2.70 me/100g and 0.50 mg kg^{-1}, respectively. According to the limits suggested by Kanwar (1976) [6], 100 % of the soils are low (<10 mg kg^{-1}) in the Sulphur status.

Soil Nutrient Index: Each individual soil samples were categorized as a whole into three fertility classes according to their nutrient index values calculated from the soil test summaries giving their percentage distribution into low, medium and high categories. As given by Muhr *et al.* (1963) [9], the nutrient index is calculated using the formulae:

$$NI=\frac{Nl + 2Nm + 3Nh}{Nl + Nm+ Nh}$$

Where, N*l* – number of samples falling in the category low
N*m* – number of samples falling in medium category and
N*h* – number of samples falling in high category.

The nutrient index value is rated as less than 1.5 is rated as low, 1.5 to 2.5 is rated as medium and more than 2.5 is rated as high fertility statusas suggested by Kumar and Shekar (2013) [7].

The Nitrogen, Phosphorus, Potassium and Sulphur Index calculated value is given in the Table 2. For nitrogen and sulphur it is low, medium for potassium and high for potassium. The soil nutrient value index of Chikkamagalur block was found to be low to medium as given in table 2.

Table 1: Soil Nutrient Index values of Chikkamagalur blockof Karnataka

S. No.	Available Nutrient	NIV	Category
1	Nitrogen	1.08	Low
2	Phosphorus	1.92	Medium
3	Potassium	2.56	High
4	Sulphur	1.00	Low

Correlation Matrix: The bulk density was found negatively and highly significantly correlated with porosity (r = -0.575**) and water holding capacity (r = -0.811**) of the soil and negatively significantly related with electrical conductivity (r = -0.409*) and available magnesium (r = -0.433*). The particle density of the soils also showed highly significant and positive relationship with porosity (r = 0.552**) and negatively with water holding capacity (r = -0.547**). There is also negative significant relationship of particle density with available nitrogen (r = -0.438*) and available sulphur (r = -0.421*). Water holding capacity of the soils is found positive and highly significantly related with organic carbon content (r = 0.552**) and available nitrogen content (r = 0.507**) and significant and positively related with electrical conductivity (r = 0.494*), available potassium (r = 0.403*) and magnesium (r = 0.481*) status of soil. The pH status of the soils were found positive and highly significant related with available potassium (r = 0.541**) and negatively significant with available sulphur (r = -0.428*) status of the soil. Similar results were observed between pH and sulphur by Bharteey *et al.*, (2017) [1] in soils of Mirzapur district of Uttar Pradesh. The electrical conductivity of the soils have shown positive and highly significant with available nitrogen (r = 0.626**) and potassium (r = 0.747**) status of the soil. The organic carbon status of the soils were positive and significantly related with available phosphorus (r = 0.502*) and potassium (r = 0.427*). This might be due to the favorable environment, high organic matter and about more than 50% of phosphorus in organic forms. Similar results were also reported by Meena *et al.* (2006) [8] and Verma *et al.* (2013) [18]. The organic carbon is also positive and highly significant with available magnesium (r = 0.840**). The available nitrogen is found positive significant relationship with available potassium (r = 0.420*). Similar findings were reported by Sudheer *et al.* (2017) [16] in Mid-Himalayan soils of Himachal Pradesh. The phosphorus status of the soils are found positive and significant relationship with available potassium (r = 0.496*) and magnesium (r = 0.396*) status of the soils.

Table 2: Soil physico-chemical properties of Chikkamagalur block of Chikkamagalur district in Karnataka.

Sample No.	Villages	BD (Mg/m^3)	PD (Mg/m^3)	Porosity (%)	WHC (%)	pH	EC (dS/m)	Organic Carbon (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Calcium (me/ 100g)	Magnesium (me/100g)	Sulphur (mg/Kg)
S_1	Mugtihalli	1.42	2.40	40.93	29.41	4.2	172	0.95	144.26	25.25	324.80	0.30	0.80	2.99
S_2	Mugtihalli	1.40	2.64	47.11	31.94	4.6	102	0.80	131.71	15.24	145.60	1.40	1.20	0.20
S_3	Mugtihalli	1.40	2.69	48.10	33.09	4.8	131	0.83	172.48	34.87	414.40	1.10	1.30	0.24
S_4	Mugtihalli	1.30	2.39	45.44	40.71	5.7	747	1.12	470.40	26.15	1500.80	2.50	2.30	0.99
S_5	Mugtihalli	1.33	2.49	46.64	36.10	6.2	170	0.80	250.88	20.99	896.00	0.80	4.00	0.58
S_6	Mugtihalli	1.41	2.57	44.99	33.72	6.4	106	0.88	72.13	20.40	448.00	1.30	2.90	0.14
S_7	Mugtihalli	1.50	2.65	43.19	29.02	6.4	99	0.73	112.90	16.04	526.40	1.70	1.30	0.39
S_8	Shirgunda	1.40	2.64	47.00	31.17	5.5	153	0.81	163.07	13.01	291.20	0.60	3.50	0.20
S_9	Shirgunda	1.39	2.67	47.84	27.37	5.1	67	0.55	109.76	10.48	212.80	1.70	1.20	0.23
S_{10}	Shirgunda	1.40	2.47	43.47	34.77	5.4	126	0.85	134.85	8.98	235.20	2.20	1.70	0.31
S_{11}	Shirgunda	1.34	2.46	45.40	35.97	6.2	167	0.83	156.80	7.72	537.60	0.10	3.80	0.16
S_{12}	Shirgunda	1.37	2.62	47.73	34.27	6.8	159	0.80	97.22	22.09	896.00	4.30	1.00	0.34
S_{13}	Shirgunda	1.45	2.54	42.82	30.08	5.7	289	0.79	106.62	12.84	705.60	1.60	2.00	0.34
S_{14}	Shirgunda	1.55	2.65	41.55	26.07	6.5	125	0.83	75.26	22.26	324.80	1.70	1.10	0.10
S_{15}	Dambadahalli	1.34	2.33	42.60	37.03	5.0	178	1.07	137.98	14.34	280.00	2.30	3.70	0.43
S_{16}	Dambadahalli	1.41	2.43	42.10	29.62	6.3	149	0.70	75.26	10.06	369.60	2.20	2.00	0.42
S_{17}	Dambadahalli	1.46	2.58	43.50	30.69	5.2	125	0.83	172.48	15.60	156.80	1.70	0.90	0.43
S_{18}	Dambadahalli	1.47	2.55	42.18	28.33	5.7	98	0.92	147.39	13.04	291.20	1.20	2.10	0.29
S_{19}	Dambadahalli	1.49	2.50	40.37	29.39	7.0	211	1.13	94.08	14.74	840.00	2.30	2.20	0.39
S_{20}	Dambadahalli	1.47	2.52	41.84	31.46	5.3	195	0.77	109.76	14.31	168.00	2.10	2.00	0.60
S_{21}	Dambadahalli	1.33	2.60	48.87	38.13	7.3	237	1.95	131.71	38.63	1030.40	0.60	12.90	0.34
S_{22}	Dambadahalli	1.48	2.44	39.56	32.03	6.7	149	0.85	417.09	12.81	448.00	1.80	3.00	0.40
S_{23}	Mattavara	1.35	2.47	45.16	35.28	5.0	207	1.19	159.94	15.40	414.40	3.10	3.90	0.62
S_{24}	Mattavara	1.34	2.43	44.69	40.35	4.9	190	1.09	197.57	10.58	291.20	3.20	2.40	1.05
S_{25}	Mattavara	1.38	2.30	39.78	40.04	4.9	185	1.15	257.15	10.55	336.00	1.20	4.20	0.42

Table 3: Correlation between soil physico-chemical properties of Chikkamagalur block of Chikkamagalur district in Karnataka

Parameters	BD	PD	Porosity	WHC	pH	EC	OC	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulphur
BD	1												
PD	0.362	1											
Porosity	-0.575**	0.552**	1										
WHC	-0.811**	-0.547**	0.243	1									
pH	0.196	0.205	0.011	-0.090	1								
EC	-0.409*	-0.382	0.036	0.494*	0.047	1							
Organic carbon	-0.381	-0.257	0.109	0.552**	0.223	0.340	1						
Nitrogen	-0.322	-0.438*	-0.094	0.507**	-0.058	0.626**	0.157	1					
Phosphorus	-0.167	0.310	0.426*	0.147	0.181	0.272	0.502*	0.083	1				
Potassium	-0.383	-0.102	0.255	0.403*	0.541**	0.747**	0.427*	0.420*	0.496*	1			
Calcium	-0.061	-0.099	-0.027	0.162	0.075	0.187	-0.052	0.004	-0.163	0.128	1		
Magnesium	-0.433*	-0.112	0.286	0.481*	0.386	0.143	0.840**	0.088	0.396*	0.367	-0.290	1	
Sulphur	-0.131	-0.421*	-0.249	0.066	-0.428*	0.238	0.121	0.180	0.198	0.048	-0.093	-0.139	1

Note: '*' represents significant at 0.05 level and '**' represents significant at 0.01 level

Conclusions

By considering the soil nutrient index of the study area, it is found the soils of the Chikkamagalur block were low in the available nitrogen and sulphur contents, medium in phosphorus and high in potassium contents of soil. The soils were found to be acidic to neutral in reaction and were free

from salinity. The organic carbon statuses of soils were found medium to high. The results have shown that the soils of Chikkamagalur block of Karnataka are deteriorating in its quality. This is mainly due to the continuous cropping. So it is recommended for the study area that sustainable cropping management systems are adopted to conserve and improve the soil quality.

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