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Physico-chemical properties of the dominant soil type under potato cultivation in Hassan district

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Abstract
Core samples for bulk density analysis and basic physico-chemical properties were drawn from the selected sites soil suitable for potato cultivation in Hassan district. The horizon wise samples were studied for, pH, EC, bulk density, organic carbon, cation exchange properties, exchangeable bases and plant available macro, secondary micro nutrients. The results of the soil analysis revealed that soil reaction ranged from 4.75 to 6.91 in different pedons and also variation was noticed with the depth of the pedons, organic carbon content of surface soil ranged from 4.2 g kg^{-1} soil to 11.1g kg^{-1} soil and in the subsoil layer 2.9 to 10.2 g kg^{-1} soil, decreasing gradually with depth. Cation exchange capacity of the soils was generally medium to low and exchange complex was dominated by calcium and magnesium. The soil available levels of other nutrients like potassium, calcium, magnesium, sulphur, iron, manganese, copper and boron was satisfactory.

Keywords: Crop production, soil physic-chemical properties, dominant soil type, Pedons, Horizon

Introduction
Potato (*Solanum tuberosum* L.) is the world's fourth most important food crop after maize, wheat and rice with an annual production approaching 405.5 million tonnes from an area of 19.7 million hectares (Anon., 2014) [1]. It is an important crop and can supplement the food needs of the country in a substantial way as it produces more dry-matter, balanced protein and more calories from unit area of land and within short time than other major food crops. The present area under potato in India is about 1.9 million hectares. India produces a total of about 45 million tonnes of potatoes every year and ranks fifth in production after China, Russian federation, Poland and Ukarine. The productivity of potato in India is about 23.68 tonnes per hectare (FAO, 2012) [4].

In Hassan district potato is grown as rainfed crop during kharif season (June to September). Farmers of Hassan district strongly believe that the complex fertilizer 20:20:0:13 and DAP are the only fertilizer best suited for potato crop and other fertilizers are costly and harmful to the crop. Thus the cultivators use 4 bags of 20:20:0:13 complexes, 2 bags of DAP and 50 kg urea ha^{-1} and this application is imbalanced application of nutrients. Under such an imbalanced application of nutrients without organic manures, it is not possible to realize the potential yield of the crop. Potato produces large amount of biomass per unit area, per unit time, compared to cereals and legumes. Consequently, its nutrient requirements are quite high (Grewal and Sharma, 1981). Although plants get some amount of major nutrients from the soil, they are inadequate to meet the crop demand. This inadequate nutrition leading to nutrient imbalance in plants is the major factor contributing to low potato production in the state.

In Hassan district, potato followed by maize is the common potato based cropping pattern. Both the crops generate large biomass and hence require heavy external inputs of plant nutrients. Opined that application of fertilizer (Urea, SSP, MOP) significantly increased the uptake of S, Ca, and Mg at different stages of the growth and by different varieties of potato. Keeping in view these facts the present study was carried out in potato growing of Hassan district Karnataka with the following objective to characterize the physico-chemical properties of dominant soil type under potato cultivation in Hassan district.

Material and methods
Study area
Hassan district is situated at southern part of the state comprising of 8 blocks. The district comes under 4 Agro climatic zones namely, Central dry zone, Southern dry zone, Southern

transitional zone and Hilly zone. According to delineation of NARP zones in the state Arasikere taluk comes under Central dry zone, Channarayapatna taluk comes under Southern dry zone, Holenarsipur, Arkalgud, Alur and Belur comes under Southern transitional zone where as Sakleshpur taluk comes under Hilly zone. Classification of soils of six sites as per soil taxonomy is given in table 1

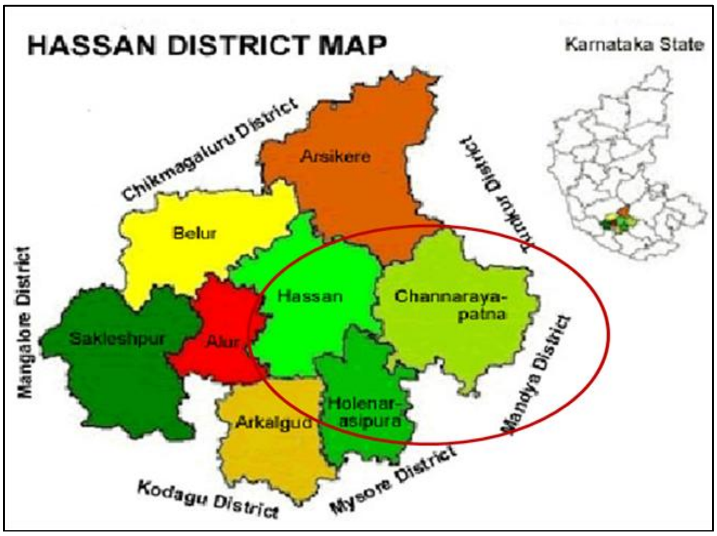

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Fig 1: Map showing the sampling sites

The sites for sampling were chosen on the basis of soil suitable for potato cultivation, microclimate, and degree of erosion, away from field boundaries, roads and rivers. The sites selected were representative of the area. A pit of 1.5 m x 1.5 m x 2 m dimension was excavated at each site of soil profile study. The soil profile was oriented in such a manner that a face was well lighted.

Soil Sampling
Soil sample from each horizon of the profile was collected in polythene bags, labeled properly and transported to laboratory for processing and analysis. Samples for determination of bulk density were collected using a metallic core of known volume which was driven into each horizon. The cutting edge of the core was pressed into the soil and driven in using a wooden hammer and then carefully removed to gather a known volume of soil sample. Duplicate core samples were collected from each horizon of the pedon. The protruding soil on either end of the core was removed.

Table 1: Classification of soils of six sites as per soil taxonomy

Site of pedon	Order	Sub order	Great group	Subgroup
Madlapura	Alfisols	Haplustalfs	Typic Haplustalfs	Fine, mixed, isohyperthermic, Typic Haplustulfs.
Kalanahalli	Alfisols	Haplustalfs	TypicHaplustalfs	Fine,loamy,mixed, isohyperthermic, Typic Haplustulfs.
Gonisomenahalii	Inceptisols	Dystrustepts	Lithic Dystrustepts	Loamy, mixed, isohyperthermic, Lithic Dystrustepts.
Chigatihalli	Alfisols	Haplustalfs	Typic Haplustalfs	Fine, mixed, isohyperthermic
Hongere	Inceptisols	Dystrustepts	Typic Dystrustepts	Clayeyskeletal,mixed isohyperthermic, Typic Dystrustepts
Sidlahosalli	Alfisols	Haplustalfs	Typic Haplustalfs	Fine, mixed, isohyperthermic

Preparation of Soil Samples
Soil samples upon arrival at the laboratory were air dried under shade. These were ground in a wooden mortar with a wooden pestle and then passed through a 2 mm sieve to separate the coarse fragments. The fine earth was stored in polythene bags for analytical purpose.

Methods of Soil Analysis
Bulk Density
Bulk density was determined gravimetrically by core sampler method. Bulk density of field moist samples and oven dry bulk density were determined for the samples. The coarse fragments (>2 mm) in core samples were separated after sieving through 2 mm sieve. Sonicator was used to separate fine particles from the gravel. The gravel was weighed after oven drying. Volume of gravel was measured by water displacement method using a measuring cylinder.

Soil Reaction (pH)
Soil pH was determined in 1:2.5 soil:water suspension, 1:2.5 soil by potentiometric method (Jackson, 1973) [10].

Electrical Conductivity
Electrical conductivity was determined in suspension of 1:2.5 soil: water extract using conductivity bridge (Jackson, 1973) [10].

Organic Carbon
The dry soil sample was powdered using agate pestle and mortar to pass through 0.2 mm sieve. A known weight of powdered sample was treated with known volume of standard $K_2Cr_2O_7$ and concentrated H_2SO_4. The unused $K_2Cr_2O_7$ was quantified by back titration with standard ferrous ammonium sulphate using ferroin indicator (Walkley and Black, 1934) [19].

Cation Exchange Capacity and Exchangeable Bases

Cation exchange capacity of soil was determined by ammonium acetate leaching method (Jackson, 1973) [10]. Ca and Mg were determined using atomic absorption spectrophotometer and sodium and potassium by flame photometry (Sarma *et al*., 1987) [15].

Extractable Acidity ($BaCl_2$-TEA)

Extractable acidity is the acidity released from the soil by $BaCl_2$-TEA solution buffered at pH 8.2. It includes all the acidity generated by replacement of H^+ and Al^{3+} from permanent and pH-dependent exchange sites. (Sarma *et al*., 1987) [15].

Extractable acidity (1 N KCl)

Extractable acidity (H^+ and Al^{3+}) was estimated by extracting the soil with 1NNaOH using phenolphthalein indicator (Sarma *et al*., 1987) [15].

Effective Cation Exchange Capacity

The effective cation exchange capacity (ECEC) was calculated as the sum of exchangeable Ca, Mg, Na, K and KCl extractable Al.

CEC Sum of Cations

The cation exchange capacity by sum of cations was
Estimated by summing up the total exchangeable bases and $BaCl_2$–TEA extractable acidity.

Available Plant Nutrients

Available phosphorus

The soil samples were both in acidic and alkaline range.
Hence, both Bray's reagent (for acid soils) and Olsen's reagent (for neutral and alkaline soils) were used for extraction. The phosphorus content in the soil extract was determined by the blue colour formed by ascorbic acid-molybdate complex and the colour intensity was read at 660 nm using spectro-photometer (Jackson, 1973) [10].

Available potassium

The exchangeable potassium was extracted with neutral normal ammonium acetate from a known quantity of soil. The filtered extract was fed to flame photometer for measuring potassium content (Page *et al*., 1982) [13].

Exchangeable calcium and magnesium

The same extract obtained for potassium was used to determine exchangeable calcium and magnesium contents also. Calcium and Magnesium were determined from the extract using atomic absorption spectrophotometer (Page *et al*., 1982) [13].

Available sulphur

The sulphate form of sulphur in soil was extracted using 0.15 per cent $CaCl_2$ solution. Sulphate in the extract was determined by developing turbidity with $BaCl_2$ and the absorbance was measured using spectrophotometer at 420 nm (Hesse, 1994) [9].

Available micronutrients

The status of micronutrients, Fe, Mn, Cu and Zn were determined by extracting the soil using 0.1 N HCl as an extractant in 1:10 ratio and 0.01 M DTPA in 1:2 ratio, shaken for 5 min and 2 hrs respectively, filtered and fed into the atomic absorption spectrophotometer. Boron in soil was extracted by refluxing with 0.02 M $CaCl_2$. The B in the extract was estimated by developing yellow colour with Azomethine H and the colour intensity was read at 420 nm (Gupta, 1967) [8].

Results

Pedon 1 Madalapura (Channarayapatna taluk)

Soil reaction was moderately alkaline in the surface layer with pH in soil water suspension at 7.78. In the subsoil horizon pH ranged from 7.6 to 8.18. The pH measured in $CaCl_2$ and KCl solutions were less than those recorded with soil water suspension. The magnitude of decrease was larger in KCl than $CaCl_2$. EC of the surface horizon was 0.08 dS m^{-1} and it dropped to 0.06 dS m^{-1} in the immediate subsoil and thereafter ranged from 0.07 to 0.10 dS m^{-1}. Organic carbon content in the surface horizon was 8.9 g kg^{-1} soil and it dropped to 6.8 g kg^{-1} soil in the immediate subsoil horizon and thereafter ranged from 5.1-3.8 g kg^{-1} soil (Table 2).

Surface horizon recorded 3.6 cmol (+) kg^{-1} soil of exchangeable calcium. Maximum exchangeable Ca (4.67 cmol(+)kg^{-1} soil) was found in the Bt22 horizon and minimum (3.94 cmol(+)kg^{-1} soil) in the B3 horizon. Exchangeable Mg in the surface horizon was 1.58 cmol (+) kg^{-1} soil. The highest content (2.49 cmol (+) kg^{-1} soil) was found in the Bt22 and the least (1.93 cmol (+) kg^{-1} soil) in the Bt21 horizon. Exchangeable potassium of 0.44 cmol (+) kg^{-1} soil was found in the surface horizon and it ranges from 0.36 to 0.78 cmol(+)kg^{-1} soil in the immediate subsoil horizon. Exchangeable Na in the surface horizon was 0.8 cmol(+)kg^{-1} soil and it ranged from 0.84 cmol(+)kg^{-1} soil to 1.13 cmol(+)kg^{-1} soil in the subsurface horizons. Base saturation per cent ranged from 56.46 to 73.03 per cent (Table 3).

Available phosphorus in the surface soil was 23.12 kg ha^{-1} soil. It declined to 11.63 kg ha^{-1} soil in the immediate subsoil horizon and thereafter less than 7.42 kg ha^{-1} soil. Available potassium in the surface horizon was 240.1 kg ha^{-1} and decreased to 158.1 kg ha^{-1} soil in the immediate subsoil horizon. Available calcium in the surface horizon was 540 mg kg^{-1} soil and ranged from 609 to 1073.1 mg kg^{-1} in the subsurface horizons. Available magnesium in the surface horizon was 161.7 mg kg^{-1} soil and ranged from 199.5 to 291.9 mg kg^{-1} soil in the subsurface horizons. Available sulphur in the surface horizon was 15.94 mg kg^{-1} soil and in the subsoil ranged from 10.80 to 22.46 mg kg^{-1} soil, increasing downward. Surface horizon had available Fe, Mn, Cu, Zn and B of 11.46, 8.78, 1.48, 0.6, 0.64 mg kg^{-1} soil, respectively. In subsoil it ranged from 2.78 to 5.66, 3.44 to 4.72, 0.62 to 1.12, 0.04 to 0.42 and 0.24 to 0.91 mg kg^{-1} soil, respectively.

Pedon 2 Kalenahalli (Holenarshipura taluk)

Soil reaction was strongly acidic in surface soil and moderate in B1 and B2 horizons. The pH measured in $CaCl_2$ and KCl solutions were less than those recorded with soil water suspension. The magnitude of decrease was larger in KCl than $CaCl_2$. Electrical conductivity ranged from 0.02 to 0.07 dS m^{-1}. Organic carbon ranged from 2.5 to 5.5 g kg^{-1} soil. The maximum was observed in B1 horizon which decreased in subsoil horizons with depth and minimum was observed in B2 and BC horizons.

Exchangeable calcium ranged from 1.52 to 2.99 cmol (+)kg^{-1} soil. The maximum was observed in B2 horizon (Table 3). The maximum exchangeable magnesium was observed in B2 horizon and minimum was observed in B1 horizon. The maximum exchangeable potassium was observed in Ap horizon and minimum was observed in BC horizon.

Extractable Al^{3+} was negligible. Cation exchange capacity ranged from 5.1 to 14 cmol (+) kg^{-1} soil. The maximum was observed insurface B2 horizon and minimum was observed in Ap horizon. Cation exchange capacity by sum of cations ranged from 19.64 to 22.85 cmol (+) kg^{-1} soil. Effective cation exchange capacity ranged from 3.1 to 6.65 cmol (+) kg^{-1} soil. Base saturation per cent ranged from 41.28 to 54.31 per cent. The maximum was observed in Ap horizon and minimum was observed in B1 horizon. The CEC/clay ratio ranged from 0.23 to 0.37. The maximum was observed in B2 horizon and minimum was observed in Ap horizon (Table 3).

Available phosphorus in the surface soil was 49.22 kg ha^{-1} soil. It ranged from 6.05 to 5.77 kg ha-1 soil in the subsoil horizons. Available potassium in the surface horizon was 134.4 kg ha^{-1} soil. It ranged from 33.6 to 44.8 kg ha^{-1} soil in subsoil horizons. Available sulphur in the surface horizon was 10.86 mg kg^{-1} soil. It ranged from 5.79 to 10.86 mg kg^{-1} soil in the subsoil horizons. Surface horizon content of available Fe, Mn, Cu, Zn and B were, 11.1, 10.8, 1.9, 0.8 and 0.42 mg kg^{-1}, respectively (Table 2). In subsoil it ranged from 7.0 to 19.6, 3.6 to 7.8, 1.5 to 2.3, 0.4 to 0.9 and 0.31 to 1.59 mg kg^{-1} soil, respectively.

Pedon 3 Gonisomenahalli (Belur taluk)

Soil reaction was slightly acidic to neutral in the soil profile. Electrical conductivity ranged from 0.06 to 0.09 dS m^{-1}. Organic carbon was 8.5 g kg-1 in surface and 6.4 g kg^{-1} in subsurface soil (Table 2).

Exchangeable calcium ranged from 4.07 to 7.14 cmol(+)kg^{-1} soil. Exchangeable magnesium ranged from 1.23 to 2.1 cmol (+) kg^{-1} soil. Exchangeable potassium ranged from 0.23 to 0.35 cmol (+) kg^{-1} soil. Exchangeable sodium ranged from 0.63 to 0.69 cmol (+) kg^{-1} soil.

$BaCl_2$-TEA extractable acidity ranged from 5.5 to 6.5 cmol(+)kg^{-1} soil. Extractable H^+ and Al^{3+} were traces (Table 3). Cation exchange capacity ranged from 13.2 to 18.8 cmol(+)kg^{-1} soil. Cation exchange capacity by sum of cations ranged from 11.72 to 16.72 cmol (+) kg^{-1} soil. Effective cation exchange capacity ranged from 6.32 to 10.32 cmol (+) kg^{-1} soil. Base saturation per cent ranged from 47.12 to 54.36 per cent. The CEC/clay ratio ranged from 0.49 to 0.59.

Available phosphorus in the surface soil was 32.5 kg ha^{-1} soil. Available potassium in the surface horizon was 184.8 kg ha^{-1} soil (Table 4). Surface horizon content of available Fe, Mn, Cu, Zn and B were, 11.20, 29.7, 3.9, 0.14 and 1.15 mg kg^{-1}, respectively. In subsoil 12.48, 16.04, 2.6, 0.28, and 1.10 mg kg^{-1} soil, respectively.

Pedon 4: Chigatihalli (Hassan taluk)

Soil reaction of surface layer was strongly acid with pH in soil water suspension at 5.02. In the immediate subsoil pH increased in soil water suspension ranging from pH 6.03 to 6.33. Electrical conductivity ranged from 0.05 to 0.12 dS m^{-1}. Organic carbon ranged from 0.8 to 6.8 g kg^{-1} soil. The maximum was observed in Ap and B1 horizon which decreased in subsoil horizons with depth and minimum was observed in B3 horizon.

Exchangeable calcium ranged from 2.60 to 12.2 cmol(+)kg^{-1} soil. The maximum was observed in B3 horizon and minimum was observed in Ap horizon. Exchangeable magnesium ranged from 1.27 to 3.41 cmol(+)kg^{-1} soil. The maximum was observed in Bt22 horizon and minimum was observed in Ap horizon. Exchangeable potassium ranged from 0.22 to 0.33 cmol(+)kg^{-1}soil. The maximum was observed in Ap horizon and minimum was observed in B3. Exchangeable sodium ranged from 0.74 to 1.45 cmol(+)kg^{-1}soil. The maximum was observed in Bt22 horizon and minimum was observed in Ap horizon.

Cation exchange capacity ranged from 11.4 to 37.0 cmol(+)kg^{-1}soil. The maximum was observed in surface B3 horizon and minimum was observed in B1 horizon. Cation exchange capacity by sum of cations ranged from 18.35 to 28.72 cmol(+)kg^{-1} soil. The maximum was observed in B3 horizon and minimum was observed in B1 horizon. Effective cation exchange capacity ranged from 5.2 to 16.8 cmol(+)kg^{-1}soil. Base saturation per cent ranged from 40 to 77 per cent. The maximum was observed in Bt22 horizon and minimum was observed in Bt23 horizon (Table 3). The CEC/clay ratio ranged from 0.24 to 0.59. The maximum was observed in B3 horizon and minimum was observed in Bt22 horizon.

Available phosphorus in the surface soil was 35.9 kg ha^{-1} soil. It ranged from 10.75 to 1.9 kg ha^{-1} soil in the subsoil horizons. Available potassium in the surface horizon was 128.8 kg ha^{-1} soil (Table 4). Available sulphur in the surface horizon was 21.1 mg kg^{-1} soil. It ranged from 10.86 to 23.18 mg kg^{-1} soil in the subsoil horizons. Surface horizon content of available Fe, Mn, Cu, Zn and B were, 8, 24.1, 2.8, 0.5 and 0.52 mg kg^{-1} respectively. In subsoil it ranged from 1.3 to 3.4, 1.3 to 6.7, 1.0 to 2.1, 0.3 to 0.4 and 0.17 to 0.56 mg kg^{-1} soil, respectively.

Pedon 5 Hongere (Hassan taluk)

Soil reaction was slightly acid to slightly alkaline in surface soil horizon. In the subsoil pH ranged from pH 5.64 to 6.32. The maximum pH was observed in Bw horizon and minimum was observed in Bc horizon. Electrical conductivity ranged from 0.02 to 0.09 dS m^{-1}. Organic carbon ranged from 5.9 to 7.2 g kg^{-1} soil. The maximum was observed in Bw followed by Ap horizon and minimum in BC (Table 2).

Exchangeable calcium ranged from 1.81 to 7.32 cmol(+)kg^{-1}soil. The maximum was observed in BC horizon. Exchangeable magnesium ranged from 0.7 to 0.1.53 cmol (+) kg^{-1} soil. The maximum was observed in BC horizon and minimum in Ap horizon. Exchangeable potassium ranged from 0.13 to 0.49 cmolv (+)kg^{-1}soil. The maximum was observed in BC horizon and minimum in Ap horizons. Exchangeable sodium ranged from 0.57 to 0.76 cmol(+)kg^{-1} soil. The maximum was observed in Bw horizon and minimum was observed in Ap.

Cation exchange capacity ranged from 8 to 23.8 cmol(+)kg^{-1} soil. The maximum was observed in BC horizon and minimum in Ap horizon. Cation exchange capacity by sum of cations ranged from 19.8 to 42.79 cmol (+)kg^{-1}soil. The maximum was observed in Bw horizon and minimum was observed in Ap horizon. Effective cation exchange capacity ranged from 3.59 to 10.2 cmol (+)kg^{-1} soil (Table 3). Base saturation ranged from 40 to 47 per cent. The maximum was observed in Bw horizon and minimum was observed in Ap horizon. The CEC/clay ratio ranged from 0.38 to 0.65. The maximum was observed in BC horizon and minimum was observed in Ap horizon.

Available phosphorus in the surface soil was 49.05 kg ha^{-1} soil. It ranged from 42 to 44 kg ha^{-1} soil in the subsoil horizons. Available potassium in the surface horizon was 44.8 kg ha^{-1} soil. It ranged from 33.6 to44.8 kg ha^{-1} soil in subsoil horizons (Table 4). Available sulphur in the surface horizon was 7.24 mg kg^{-1} soil. It ranged from 6.04 to 7.24 mg kg^{-1} soil in the subsoil horizons. Surface horizon content of available

Fe, Mn, Cu, Zn and B were, 9.8, 6.5, 1.5, 1.5 and 1.66 mg kg^{-1}, respectively. In subsoil it ranged between 5.6 and 9.3, 3.2 and 2.7, 0.9 and 2.2, 0.5, 1.12 and 0.7 mg kg^{-1}soil in Bw and BC horizon, respectively.

Pedon 6: Sidlahosalli (Hassan taluk)

Soil reaction was moderately acid in surface soil horizon. In the immediate subsoil pH of soil water suspension ranged from pH 5.8 to 5.23. The maximum pH was observed in Bt21 horizon and minimum was observed in Ap horizons. Electrical conductivity decreased with depth and it ranged from 0.02 to 0.04 dS m^{-1}. Organic carbon ranged from 11.1 to 0.8 g kg^{-1} soil. The maximum was observed in Ap horizon which decreased with the depth and minimum was observed in BC2 horizon (Table 2).

Exchangeable calcium ranged from 1.42 to 3.70 cmol(+)kg^{-1}soil. The maximum was observed in Bt22 and minimum was observed in Bt23 horizon. Exchangeable Magnesium ranged from 1.23 to 0.44 cmol(+)kg^{-1}soil. The maximum was observed in Ap horizon and minimum was observed in Bt23 horizon. Exchangeable potassium ranged from 0.08 to 0.18 cmol(+)kg^{-1}soil. The maximum was observed in Bt23 horizon and minimum was observed in Bc2 horizon.

$BaCl_2$-TEA extractable acidity ranged from 7.50 to 21.5 cmol(+)kg^{-1}soil. The maximum was observed in Ap horizon and it decreased with depth in subsoil horizons and minimum was observed in BC2 horizon. Extractable H^+ ranged from 0.08 to 0.15 cmol(+)kg^{-1}soil. The maximum was observed in Bt22 and Bt23 horizon and minimum was observed in Ap, Bt21 horizon. Extractable Al3+ was observed 0.1 cmol(+)kg^{-1}soil in Ap, Bt21 and Bt22. Cation exchange capacity ranged from 09.40 to 16.23 cmol(+)kg^{-1}soil. The maximum was observed in surface Bt22 horizon and minimum was observed in Bt23 horizon (Table 3). Cation exchange capacity by sum of cations ranged from 12.21 to 25.82 cmol(+)kg^{-1} soil. The maximum was observed in Ap horizon it decreased with depth in subsoil horizons and minimum was observed in BC2 horizon. Effective cation exchange capacity ranged from 2.72 to 5.85 cmol(+)kg^{-1}soil. The maximum was observed in BC1 horizon and minimum was observed in Bt23 horizon. Base saturation per cent ranged from 27 to 39 per cent. The maximum was observed in Ap horizon it decreased with the depth in subsoil horizons and minimum was observed in Bt23 horizon. The CEC/clay ratio ranged from 0.2 to 0.49. The maximum was observed in Bc1 horizon and minimum was observed in Bt23 horizon.

Available phosphorus in the surface soil was 44.00 kg ha^{-1} soil. It ranged from 03.30 to 26.15 kg ha-1 soil in the subsoil horizons. Available potassium in the surface horizon was 145.6 kg ha^{-1} soil. It ranged from 28 to 56 kg ha^{-1} soil in subsoil horizons. Available calcium in the surface horizon was 860 mg kg^{-1} soil it decreased with the depth. It ranged from 616 to 763 mg kg^{-1} in subsoil horizons. Available magnesium in the surface horizon was 156 mg kg^{-1} soil and decreased abruptly in the immediate subsoil horizon. It ranged from 103 to 136 mg kg^{-1} soil in the subsoil horizons (Table 4). Available sulphur in the surface horizon was 9.91 mg kg^{-1} soil. It ranged from 14.49 to 7.24 mg kg^{-1} soil in the subsoil horizons. Surface horizon content of available Fe, Mn, Cu, Zn and B were, 20.3, 12.2, 2.9, 0.9 and 0.8 mg kg^{-1}, respectively. In subsoil it ranged from 1.8 to 11.2, 2.8 to 5.2, 1 to 1.7, 0.2 to 0.8 and 0.38 to 1.26 mg kg^{-1} soil, respectively

Table 2: Horizon wise pH, Organic carbon, Electrical conductivity and Bulk density of soil profile sampled at soil suitable for potato cultivation in Hassan district

Depth (cm)		pH			Organic	Electrical	Bulk density (Mg m^{-3})	
	Horizon	(1:2.5) Water	(1:2.5) 0.02*M* $CaCl_2$	(1:2.5) 1.0 *M* KCl	carbon (g kg^{-1})	conductivity dS m^{-1}	Field moist	Oven dry
Pedon 1: Madalapura (Channarayapatna taluk)								
0-14	Ap	7.78	6.91	6.76	8.9	0.080	1.61	1.35
14-39	Bt21	8.18	7.21	6.95	6.8	0.056	1.48	1.41
39-51	Bt22	7.90	7.19	6.80	5.1	0.079	-	-
51-80	Bt23	7.60	7.17	6.70	4.2	0.107	-	-
80-100	B3	7.82	7.15	6.68	3.8	0.084	-	-
Pedon 2: Kallenahalli (Holenarasipura taluk)								
0-20	Ap	4.78	4.62	4.39	4.2	0.070	1.51	1.52
20-39	B1	5.53	5.13	4.58	5.5	0.039	1.72	1.49
39-80	B2	5.65	5.45	4.80	2.9	0.052	1.66	1.32
Pedon 3: Gonisomenahalli (Belur)								
0-18	Ap	6.63	6.50	6.12	8.5	0.096	1.41	1.38
18-33	Bw	7.12	6.73	6.20	6.4	0.063	1.64	1.52
Pedon 4: Chigatihalli (Hassan taluk)								
0-18	Ap	5.02	4.75	4.50	6.5	0.052	1.37	1.31
18-32	B1	6.33	6.20	5.84	6.8	0.069	1.56	1.46
32-65	Bt21	6.16	6.09	5.74	5.8	0.098	1.66	1.43
65-104	Bt22	6.15	6.11	5.75	5.4	0.123	1.70	1.44
104-128	Bt23	6.03	5.97	5.60	4.2	0.082	1.78	1.51
128-166	Bt24	6.25	6.15	5.76	3.8	0.077	1.87	1.51
166-194	B3	6.31	6.25	5.74	0.8	0.092	1.76	1.60
Pedon 5: Hongere (Hassan taluk)								
0-22	Ap	6.21	5.96	5.37	6.7	0.028	1.51	1.52
22-56	Bw	6.32	6.07	5.41	7.2	0.031	1.72	1.69
56-86	BC	5.64	5.55	4.78	5.9	0.096	1.66	1.72
Pedon 6: Sidlahosahalli (Hassan Taluk)								
0-14	Ap	5.50	5.37	5.02	11.1	0.040	1.31	1.22
14-34	Bt21	5.81	5.41	4.98	10.2	0.024	1.74	1.51
34-54	Bt22	5.44	5.17	4.73	8.50	0.028	1.50	1.31
54-69	Bt23	5.23	5.19	4.80	5.10	0.036	1.66	1.42
69-100	Bt24	5.51	5.42	5.10	2.90	0.033	1.50	1.27
100-129	BC1	5.59	5.41	5.26	2.90	0.035	1.71	1.55
129-164	BC2	5.78	5.74	5.23	0.80	0.032	1.81	1.56

Table 3: Depth wise Exchangeable bases, acidity, Cation exchange capacity, Base saturation and Ratio CEC/ Clay of soil profile sampled at soil suitable for potato cultivation in Hassan district

Depth (cm)	Exchangeable bases					Extractable acidity			Cation exchange capacity			Base saturation		Ratio CEC/ Clay
	Ca	Mg	Na	K	Tot	$BaCl_2$-TEA	1.0 N KCl		NH_4OAc (pH 7.0)	Sum of cations	ECEC	NH_4OAc	Sum of cations	
							H^+	Al^{3+}						
	cmol (+) kg^{-1} soil											%		
Pedon 1: Madalapura (Channarayapatna taluk)														
0-14	3.60	1.58	0.80	0.44	6.42	10.50	0.10	-	8.9	16.92	6.5	72.13	37.94	0.54
14-39	4.07	1.93	0.84	0.49	7.33	12.60	0.10	-	11.2	19.93	7.4	65.44	36.78	0.30
39-51	4.67	2.49	1.07	0.78	9.01	9.50	0.08	-	13.9	18.51	9.1	64.82	48.68	0.31
51-80	4.12	2.36	1.13	0.52	8.13	14.08	0.13	-	14.4	22.21	8.2	56.46	36.61	0.28
80-100	3.94	2.14	1.01	0.36	7.45	13.40	0.10	-	10.2	20.85	7.5	73.03	35.73	0.37
Pedon 2: Kallenahalli (Holenarasipura taluk)														
0-20	1.52	0.39	0.57	0.15		18.14	0.23	-	5.1	19.64	3.1	70.12	41.28	0.23
20-39	2.65	0.95	0.72	0.19		17.23	0.19	-	12.65	20.74	5.16	65.24	48.57	0.28
39-80	2.99	1.31	0.86	0.24		15.23	0.08	-	14.0	22.85	6.65	67.52	54.31	0.37
Pedon 3: Gonisomenahalli (Belur)														
0-18	4.07	1.23	0.69	0.23	6.22	5.50	0.1	-	13.2	11.72	6.32	47.12	53.07	0.59
18-33	7.14	2.10	0.63	0.35	10.22	6.50	0.1	-	18.8	16.72	10.32	54.36	61.12	0.49
Pedon 4: Chigatihalli (Hassan taluk)														
0-18	2.60	1.27	0.74	0.33	4.94	18.30	0.13	0.1	11.6	23.24	5.20	42.59	21.26	0.34
18-32	3.83	1.49	1.34	0.29	6.95	11.40	0.05	-	11.4	18.35	7.00	60.96	37.87	0.40
32-65	3.12	1.93	1.37	0.23	6.65	13.98	0.13	-	16.2	20.63	6.80	41.05	32.23	0.30
65-104	6.43	3.41	1.45	0.26	11.55	10.96	0.20	-	15.0	22.51	11.7	77.00	51.31	0.24
104-128	4.33	1.44	1.18	0.23	7.18	14.15	0.05	-	17.6	21.33	7.20	40.80	33.66	0.33
128-166	7.38	2.10	1.09	0.26	10.83	18.47	0.17	-	27.1	29.30	11.1	40.00	36.96	0.40
166-194	12.2	3.11	1.18	0.22	16.71	12.01	0.08	-	37.0	28.72	16.8	45.16	58.18	0.59
Pedon 5: Hongere (Hassan taluk)														
0-22	1.81	0.70	0.57	0.13	3.21	13.0	0.18	0.2	8.0	16.21	3.50	40.13	19.80	0.38
22-56	6.17	1.44	0.76	0.23	8.60	11.5	0.10	-	18.2	20.10	8.70	47.25	42.79	0.42
56-86	7.32	1.53	0.71	0.49	10.05	14.6	0.15	-	23.8	24.65	10.2	42.23	40.77	0.65
Pedon 6: Sidlahosahalli (Hassan Taluk)														
0-14	2.36	1.14	0.69	0.13	4.32	21.50	0.08	0.1	11.00	25.82	4.50	39.27	16.73	0.28
14-34	2.44	0.44	0.65	0.17	3.70	12.50	0.08	0.1	11.60	16.20	3.88	31.90	22.84	0.29
34-54	3.70	0.79	0.55	0.10	5.14	14.50	0.15	0.1	16.23	19.64	5.39	31.67	26.17	0.38
54-69	1.42	0.26	0.71	0.18	2.57	13.98	0.15	-	9.40	16.55	2.72	27.34	15.53	0.20
69-100	3.39	1.01	0.78	0.14	5.32	12.50	0.10	-	15.40	17.82	5.42	34.55	29.85	0.30
100-129	3.68	1.23	0.71	0.13	5.75	9.20	0.10	-	16.04	14.95	5.85	35.85	38.46	0.49
129-164	3.12	0.92	0.59	0.08	4.71	7.50	0.10	-	15.40	12.21	4.81	30.58	38.57	0.43

Table 4: Depth wise available nutrients of soil profile sampled at soil suitable for potato cultivation in Hassan district

	Available nutrients									
Depth (cm)	**Phosphorus**	**Potassium**	**Calcium**	**Magnesium**	**Sulphur**	**Iron**	**Manganese**	**Copper**	**Zinc**	**Boron**
	kg ha^{-1}					**mg kg^{-1} soil**				
Pedon 1: Madalapura (Channarayapatna taluk)										
0-14	23.12	240.1	540.0	161.7	15.94	11.46	8.78	1.48	0.60	0.64
14-39	11.63	158.1	1073.1	291.9	10.80	3.40	4.48	0.80	0.42	0.24
39-51	7.42	143.0	1018.5	275.1	13.76	5.66	3.90	1.12	0.36	0.52
51-80	3.62	80.70	804.3	238.3	21.01	3.22	3.44	0.62	0.04	0.91
80-100	1.04	38.21	609.0	199.5	22.46	2.78	4.72	0.68	0.16	0.43
Pedon 2: Kallenahalli (Holenarasipura taluk)										
0-20	49.22	134.4	357.0	102.9	10.86	11.1	10.8	1.9	0.8	0.42
20-39	5.77	33.60	711.9	152.9	5.79	9.30	3.60	2.3	0.4	0.44
39-80	6.05	44.80	803.2	174.3	10.86	7.00	4.00	2.2	0.4	0.31
Pedon 3: Gonisomenahalli (Belur)										
0-18	32.5	184.8	960.75	210.00	12.31	11.20	29.70	3.9	0.14	1.15
18-33	12.2	78.40	1518.3	257.25	07.97	12.48	16.04	2.6	0.28	1.10
Pedon 4: Chigatihalli (Hassan taluk)										
0-18	35.90	128.8	730.80	199.5	21.10	8.0	24.1	2.8	0.5	0.52
18-32	10.75	123.2	763.30	210.0	10.86	3.4	6.70	2.1	0.4	0.17
32-65	3.85	61.60	989.90	235.0	17.36	3.0	2.70	1.9	0.3	0.22
65-104	4.40	67.20	1067.80	115.0	23.18	1.5	3.10	1.5	0.3	0.17
104-128	2.20	50.40	894.60	171.5	16.66	3.1	3.00	2.0	0.3	0.38
128-166	1.90	72.80	2220.70	279.3	18.83	1.3	1.80	1.3	0.3	0.19
166-194	1.90	39.20	2653.30	302.5	14.49	1.3	1.30	1.0	0.4	0.56
Pedon 5: Hongere (Hassan taluk)										
0-22	49.05	44.8	959.70	137.5	7.24	9.8	6.5	1.5	1.5	1.66

22-56	42.00	44.8	1965.6	258.3	7.24	5.6	3.2	0.9	0.5	1.12
56-86	44.00	33.6	712.95	149.1	6.04	9.3	2.7	2.2	0.5	0.70
Pedon 6: Sidlahosahalli (Hassan Taluk)										
0-14	44.00	145.6	859.9	156.45	9.90	20.3	12.2	2.9	0.9	0.80
14-34	26.15	56.00	729.7	105.00	7.20	11.2	5.20	1.0	0.8	0.75
34-54	7.15	44.80	657.3	103.00	10.8	3.20	3.60	1.6	0.4	1.26
54-69	5.22	44.80	786.4	136.60	14.4	1.80	3.90	1.9	0.4	1.10
69-100	2.75	33.60	616.7	108.15	10.1	2.90	3.40	1.7	0.8	0.59
100-129	4.67	33.60	716.1	119.70	8.59	2.80	4.30	1.3	0.3	0.43
129-164	3.30	28.00	763.1	126.00	7.97	8.70	2.80	1.3	0.2	0.38

Discussion

Soils can be considered to belong to medium to high level in content of organic carbon. However, it is debatable whether the organic carbon content is at sufficient level to ensure good soil quality in the light of dominance of low clay in the highly weathered soils.

The maintenance of high level of organic matter is essential for highly weathered soils of tropics. In tropical highly wreathed soils, the source for variable charge collides are predominantly organic matter, and hydroxides and hydrous oxides of iron and aluminium with minor contributions from broken edges of silicate clay minerals, in particular Kaolinite (Baert and Van Rost, 1998) [2]. The various colloids have individual zero point charges (ZPC or pH0) values *i.e*. 6.5 to 9 for iron and aluminium hydroxides and around 4 for organic matter (Greenland and Mott, 1978; Uhera and Gilman, 1981) [6, 17]. The proportion of various colloids in the soil will determine the overall pH0 values. Iron rich soils with low organic matter content will have high pH0 values while high organic matter content will lower pH0. When soil pH < pH0 the variable charge sites carry a net positive charge conversely, they are negatively charged when soil pH> pH0.the maintenance of high levels of soil organic matter thus ensures net negative charge and consequent benefits to soil system. Organic carbon content of surface soil ranged from 4.2 g kg^{-1} soil to 11.1g kg^{-1} soil and in the subsoil layer 2.9 to 10.2 g kg^{-1} soil, decreasing gradually with depth by conventional classification of soil carbon content (low < 5; medium 7.5 and high >7.5 g kg^{-1} soil).

Bulk density of surface soil ranged from 1.22 to 1.52 Mg m^{-3} with higher values set to relatively higher proportion of sand in particle size distribution of the soil. Bulk density measured into the subsoil horizons in all the pedons studied and ranged from 1.27 to 1.70 Mg m^{-3} with mean above 1.5 Mg m^{-3}. In the absence of significant amount of organic matter in the soil, sand and gravel content largely controlled the bulk density of soil.

Electrical conductivity of soil studied were insignificant indicating only negligible amount of soluble salts. The soil reaction in surface soil ranged from very strongly acid (pH 4.78) to slightly alkaline (pH 7.78) with most in acidic in reaction. The pH increased into the subsoil horizon. Many authors (Sathyanarayana and Thomas, 1962; Van wambeke *et al*., 1983) [16, 18] reported increase in pH with depth of soils. The lower pH of surface soils is indicative of higher degree of leaching from surface and its accumulation in subsoils. The acid reaction of soils in semi-arid to subhumid environment can only be due to high inputs of nitrogenous and phosphate fertilizers. The presence of high levels of phosphorous evidence to this conclusion.

The cation exchange capacity (NH_4OAC method) of the surface soils ranged from 5.1 to 13.2 c mol (p+) kg^{-1} soil and in the subsoil from 7.8 to 37.0 cmol (p+) kg^{-1} soil with values above 20 recorded for only few instances in lowest horizons. Low CEC for soils of Bangalore Plateau was reported by many authors and they attributed this to dominance of kaolinite type of clay minerals in these soils (Basavaraj, 1989; Gowaikar and Datta, 1971; Rangaswamy *et al*., 1978; Natarajan, 1995) [3, 5, 14, 12]. However the ECEC ranged only from 3.10 to 6.5 c mol (p+) kg^{-1} soil in surface and in subsoil layers 2.0 to 7.32 c mol (p+) kg^{-1} soil. These soils cannot be described as low activity clay soils as the cation exchange capacity calculated on cent percent clay basis exceeded 24 cmol (p+) kg clay. Again, CEC/clay ratio in the range of 0.3 to 0.5 perclude dominance of low activity clay.

Exchangeable calcium in surface soil ranged from 1.52 to 4.07 c mol (p+) kg^{-1} soil and in the subsoil 2.0 to 12.2 cmol (p+) kg^{-1} soil. Exchangeable magnesium in surface ranged from 0.44 to 1.58 cmol (p+) kg^{-1} soil and in subsoil 0.4 to 3.5. Calcium and magnesium saturation of the exchange complex is sufficient to meet the plant needs despite acidification of the soils. However, that is not the case with potassium, the plant nutrient required in much larger quantities than Ca and Mg. Surface and subsoil layers have only limited quantity of potassium on exchange complex, pointing to the insignificant movement between non labile and labile pools of K, against large plant uptake. KCl extractable activity (Al and H) are quite negligible.

The soils are fairly saturated with bases (NH_4OAC method) with surface soils ranging from 40 to 72 per cent and in subsoil 27 to 73 per cent. CEC/clay ratio in the range of 0.30 to 0.5 indicates mixed mineralogy with fair proportion of low and high activity clay minerals.

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