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FORMS AND DISTRIBUTION OF POTASSIUM IN DEEP SUBTROPICAL SOILS AS INFLUENCED BY VARYING PARENT MATERIALS AND ELEVATION

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ABSTRACT

A study was conducted on some deep subtropical soils occurring in West Bengal and Jharkhand state of India with an objective to examine the effect of varying parent materials and elevation on the distribution of soil potassium fractions with depth of soil. Total potassium (K) content varied widely between 0.017 and 0.770 per cent with pedons mean ranging between 0.024 and 0.44 per cent, while HCl- soluble potassium varied between 0.009 and 0.50 per cent with pedons mean ranging from 0.012 to 0.22 per cent. Water soluble, exchangeable and available potassium in pedons varied between 5.0 and 39.2 ppm, 39.16 and 744.04 ppm and 38.43 and 773.34 ppm respectively. The overall results revealed that irrespective of elevation, exchangeable- K and available-K were higher in soils developed on parent materials 'Basic/Calc-schist' ,'Basic (Deccan trap)' and 'Calc-schist admixed with detrital laterized material' as compared to others. Soils dominant with kaolinite or illite clay mineral were more weathered containing less exchangeable and available – K. Soil on meta-amphibolite parent material exhibited very low total - K and lattice-K. Pedons with higher CEC and clay content showed higher total K content. Further, total - K and lattice-K were largely depended on the stage and degree of weathering of varying parent materials.

KERWORDS: Deep Subtropical Soils, Forms of Potassium, Distribution of Potassium, Varying Parent Materials and Elevation

INTRODUCTION

The most abundant cation in plants and which is absorbed in large quantities by roots from soil for attending several activities in the plant is "Potassium" (K). The bulk of the potassium in soil is known to be present in the mineral form as feldspars (orthoclase, microcline) and micas (biotitic, muscovite), micaceous clay or illite.The soil potassium is usually divided into three categories: non-exchangeable, exchangeable and water soluble which are in some sort of equilibrium, the magnitude of which is a function of mineralogical make up depending upon the type of parent material, stage of weathering and particle size. Water soluble - K content is the immediately plant available forms of K which generally constitutes less than 1% of the total K. Exchangeable - K which contributes to about 2.0-3.1 % of the total- K, also forms major pool of immediate plant available - K. Non- exchangeable pools of K which lies in the range of 2.5-4.2 %, is quite important from the point of K nutrition in the long run. The potassium content of acid laterite, lateritic, leached foothills soils of subtropical area, exhibit parallelism with the magnitude of interaction of intensity and capacity factors to the extent that highly leached soils register very low values of total K (Mondal *et al.*, 1975). The present paper deals with an objective to examine the effect of varying parent materials and elevation on the distribution of soil potassium fractions with depth of soil and also to discuss that in relation to the extent of weathering of some subtropical soils from West

Bengal and Jharkhand state of India.

METHODS AND MATERIALS

Study Area in Brief

The area under study falls under humid tropical to subtropical climate lying between north latitude of $22^0$15' and $23^0$45' and east longitude of $84^0$0' and 87^o30' forming parts of Ranchi and Palamau districts of Jharkhand comprising of high level aluminous laterite which extends through Purulia and farther to the western fringe of West Bengal as low level lateritic soils. The soils over the area have developed on three stepped erosion geomorphic surfaces (Niyogi, 1987). Details of geomorphic surfaces, elevation / altitude, parent materials, soils formed and their classification are already reported earlier by Das (2010).

Sample Collection and Analysis

Soil samples were collected from nine representative pedons from the above study area. Seven pedons were dug out at places of Kharagpur, Kurchiboni, Silda, Labani, Bara Ara, Lalgutuwa and Netarhat, respectively at 50, 215, 234, 245, 275, 590 and 1037 m elevation above msl. At Garbeta (150 m above msl) and Bagru (1050 m above msl) samples were taken respectively from a *Nalla* (earlier *c*utting) and a quarry where Indian Aluminium Company had mined earlier for bauxite ore. Soil sampling from different depths were done following standard procedure. Characteristics of pedons were already reported earlier by Das (2010). Excepting those of very deep pedons and whose horizonization was not distinct, all the other sola were sampled according to pedogenic horizon employing standard techniques (Soil Survey Staff, 1971). Samples were air-dried, crushed and sieved through 2 mm sieve (ASTM) and then were analyzed for Total potassium, HCl- Soluble potassium (lattice-K), Water soluble- K, Exchangeable- K, and Available -K. Total potassium was determined by soil – Na_2CO_3 fusion procedure as described by Jackson (1973). Water soluble -K and available- K was determined by flame-photometer respectively from the extracted solution obtained by shaking soil with water (1 : 5:: soil : water) for one hour and from the leachate obtained with neutral 1N NH_4OAC solution (Jackson, 1973). Exchangeable- K was computed as the difference of available potassium and water soluble potassium.

RESULTS AND DISCUSSION

The distribution of different forms of potassium in pedons developed on varying parent materials and elevation are presented in Table 1**.** The results obtained are described below.

Total Potassium

Total potassium (K) content varied widely between 0.017 and 0.770 per cent with pedon mean value ranging between 0.024 and 0.44 per cent (Table 1). The variation in total content of K in pedons was largely depended on the stage and degree of weathering coupled with type of parent material on which they developed i.e. the content of total –K varied widely in soils like, *Ultic Haplustalf, Kanhaplic Haplustult, Oxic Rhodustalf, Typic Chromustert, Ultic Haplustalf, Andic Eutropept, Oxic Rhodustult, Vertic Eutropept, Typic Kadiustult* developed respectively on alluvium, alternate cross-bedded sandstone and shale, calc-schist admixed with detrital laterized material, basic/Calc-schist, phyllite, meta-amphibolites, granitic-gneiss, basic (Deccan trap), granite parent materials at different elevations (Table 1). However, the lowest and the highest value of total K were associated with Bara Ara and Labani respectively, while the same for mean total K were obtained at same soils. Medium to low total potassium content of these pedons suggested that there might not be appreciable quantum of K- bearing primary or secondary minerals in these subtropical soils. The textural composition seemed to have controlled the distribution of total- K in pedons at Kharagpur, Labani and kurchiboni, where potassium was found to increase down the pedon. In rest of the pedons no such distribution trend of total K had been observed. Irrespective of parent material, pedons having higher CEC and clay content were found to have improved in their total K content.

Due to the weathering action of soil minerals and release of K from residues and vegetation debris, K might be set free to soil solution which in turn enter the inter lattice spaces.

HCL - Soluble Potassium (Lattice-K)

HCl- soluble potassium, in general, varied widely between 0.009 and 0.50 per cent with pedon mean value ranging between 0.012 and 0.22 per cent. The lowest and the highest value had been associated with Bara Ara and Silda pedons respectively i.e. in soils developed on Meta-amphibolites and basic / calc-schist parent material. However, the lowest and the highest mean HCl- soluble potassium were also obtained at Bara Ara and Silda respectively. Kharaghpur, Labani and Kurchiboni pedons showed clear indication of HCl - soluble lattice-K increment with depth which in turn suggested a gradual increase of illitic clay down the profile (Table 1). In Bara Ara, Lal Gutwa and Netarhat i.e. soils developed at 275, 590 and 1037 m altitude respectively on Meta-amphibolites, Granitic-gneiss and Basic (Deccan trap) content of HCl - soluble K in pedons was comparatively low. However, soils with less than 350 mg kg^{-1} of non - exchangeable K came under the categorization of low in reserve K with respect to non - exchangeable K.

Water Soluble, Exchangeable and Available Potassium

Water soluble, exchangeable and available potassium in pedons varied widely between 5.0 and 39.2 ppm, 39.16 and 744.04 ppm and 38.43 and 773.34 ppm respectively depending upon parent materials and extent of soil weathering. The data (Table 1) showed that water soluble, exchangeable and available potassium were comparatively higher for pedons derived from basic parent rock at high elevation and also on 'calc-schist with overlying detrital material' at lower elevation. The pedon mean value of water soluble potassium on basic parent rocks at Kurchiboni, Silda and Netarhat were 17.92, 19.08 and 21.26 ppm respectively, while the pedons derived from materials of acidic nature, at Bagru, Lal Gutuwa, Labani, Kharagpur, Bara Ara and Garbeta depicted the mean value of water soluble-K around 10. Similar trend had been observed also for exchangeable and available - K. The former soil group associated with basic parent materials showed pedon mean exchangeable and available - K between 231.05 and 447.20 ppm, and 224.8 and 446 ppm, respectively, whereas the corresponding values for the latter group of soils were between 40.73 and 108.08, and 51.03 and 118.6 ppm, respectively. Water soluble - K content, the immediately plant available forms of K, varied widely among soil groupings, ranging from 2.8 to 38.6 mg kg^{-1} with significantly higher quantities occurring in non – volcanic soils.

CONCULSIONS

From the overall results it can be concluded that irrespective of elevation, exchangeable- K and available-K were higher in soils developed on parent materials 'Basic/Calc-schist' ,'Basic (Deccan trap)' and 'Calc-schist admixed with detrital laterized material' as compared to others. Soils dominant with kaolinite or illite clay mineral were more weathered containing less exchangeable and available – K. Soil on meta-amphibolite parent material exhibited very low total - K and lattice-K which again were largely depended on the stage and degree of weathering of varying parent materials. Pedons with higher CEC and clay content showed higher total K content.

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APPENDICES

Table 1: Forms and Distribution of Potassium in Pedons Developed on Varying Parent Materials and Altitude Name of soil with altitude (m)

Characters	Kharagur (50)	Garbeta (150)	Kurchiboni (215)	Silda (234)	Labani (245)	Bara Ara 275)	Lal Gutuwa (590)	Netarhat (1037)	Bagru (1050)
Soil depth (m)	0 .0- 2.25	0.0-5.95+	0.0-2.10	0.0-3.65+	0.0-2.15	0.0-4.25+	0.0-3.20+	0.0-1.76	0.0-18.50+
No. of horizons	Five	Twelve	Six	Five	Five	Six	Five	Eight	Seven
water soluble K(ppm)	8.0-12.1 (10.18)	8.5-13.2 (11.87)	10.2-29.8 (17.12)	10.0-29.3 (19.08)	7.0-15.8 (10.52)	7.0-10.4 (8.60)	7.1-15.3 (10.30)	12.0-39.2 (21.26)	5.0-7.3 (6.20)
Exch. K (ppm)	43.07-78.32 (64.22)	39.16-129.23 (73.75)	39.16-626.56 (231.05)	109.64-744.04 (447.20)	78.32-137.06 (108.08)	43.07-70.49 (54.17)	31.33-70.49 (40.73)	164.47-411.18 (289.78)	39.16-58.74 (46.01)
HCl-soluble K(%)	0.14-0.20 (0.20)	0.07-0.24 (0.13)	0.11-0.40 (0.19)	0.03-0.50 (0.22)	0.12-0.35 (0.21)	0.009-0.016 (0.012)	0.061-0.091 (0.071)	0.041-0.160 (0.095)	0.015-0.270 (0.155)
Total K(%)	0.34-0.50 (0.42)	0.15-0.44 (0.26)	0.26-0.73 (0.37)	0.06-0.77 (0.39)	0.25-0.77 (0.44)	0.017-0.036 (0.0243)	0.098-0.171 (0.133)	0.085-0.286 (0.178)	0.034-0.571 (0.311)
Available K(ppm)	51.07-90.42 (74.40)	48.46-142.23 (85.62)	53.46-656.36 (248.17)	119.64-773.34 (466.28)	89.73-152.86 (118.60)	51.27-78.49 (62.80)	38.43-85.79 (51.03)	177.47-450.38 (311.04)	44.16-66.04 (52.16)
Clay minerals *	I,K(major) and M (minor)	K and I almost in equal proportion. At few depths k<I	K, M and/or I in varying proportions with depth	M dominant followed by I and K	M, K and I in varying proportions with depth	M (in upper horizons) or V (in lower horizons) dominant; K (minor)	K (dominant)M (minor to trace)	Poorly expanding M/V dominant, K (minor)	K, I (in upper horizon), K,G (in Lower Horizons)
Soil Great group	*Ultic Haplustalf*	*Kanhaplic Haplustult*	*Oxic Rhodustalf*	*Typic Chromustert*	*Ultic Haplustalf*	*Andic Eutropept*	*Oxic Rhodustult*	*Vertic Eutropept*	*Typic Kadiustult*
Parent materials	Alluvium	Alternate cross-bedded sandstone and shale	Calc-schist admixed with detrital laterized material	Basic/ Calc-schist	Phyllite	Meta-amphibolites	Granitic-gneiss	Basic (Deccan trap)	Granite

* K, I, M, V & G denote kaolinite, illite, montmorillonite, vermiculite clay minerals and gibbsite respectively.