Original Research Article

Study of Soil Nutrient Status of Doddavaram microwatershedin Koyyuru mandal of Visakhapatnam district, Andhra Pradesh

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ABSTRACT

Aims: To asses the fertility status of the soils of Doddavaram microwatershed of Koyyuru mandal of Visakhapatnam district, Andhra Pradesh in which twenty soil profiles were studied for soil physico-chemical properties (pH, EC, OC) and soil nutrient status (N, P_2O_5, K_2O, Zn, Cu, Fe and Mn).

Study design: The soil profiles were selected based on the slope and its heterogeneity

Place and Duration of Study: Doddavaram microwatershed of Koyyuru mandal of Visakhapatnam district, Andhra Pradesh located in between 17° 38' 8.765" to 17° 41' 43.100" of North latitudes and 82° 13' 2.884" to 82° 14' 5.422" of East longitudes

Methodology: Preliminary traverse of the entire watershed was carried out using 1:10,000 scale base map and satellite imagery. After delineating the landform on the satellite image, intensive traversing of each landform was undertaken to select the representative areas for transect study based on geology, drainage pattern, surface features, slope characteristics and land use, landforms and physiographic divisions. Transects were located across the slope at right angles to the contours and covers most of the variations observed in a landform. In each selected transect, profiles were located at closely spaced intervals to take care of any change in the land features like break in slope, erosion, gravels and stones *etc* . In this way totally twenty (20) soil profiles were opened and soil samples were collected and analyzed in the laboratory for soil nutrient status.

Results: The results revealed that the soils of Doddavaram microwatershed were very strongly acidic to slightly alkaline (4.58 to 7.82) in reaction, non-saline (0.02 to 0.17 dS m^{-1}), low to high (0.10 to 0.78%) in organic carbon. Moreover, these soils were low to medium in available nitrogen (28.30 to 147.14 mg kg^{-1}), available phosphorus (2.19 to 14.78 mg kg^{-1} P_2O_5) and available potassium (27.63to 117.44 mg kg^{-1}soil). The available sulphur content in the soils varied from deficient (1.41 mg kg^{-1}) to sufficient (20.83 mg kg^{-1} soil). The surface horizons of pedons 1,2,9,10,11,13,14,15,16,1718,19 and 20 were sufficient in DTPA extractable zinc, while the pedons 3,4,5,6,7,8 and 12 showed deficient levels in the surface horizons. Moreover, the zinc concentration in the sub-surface horizons was sufficient to deficient. The surface and sub-surface horizons of all the pedons in the study area of Doddavaram microwatershed were found to be sufficient in DTPA extractable copper, iron and manganese and found to be above the critical limits.

Conclusion: The analysis of macronutrients in the soils of Doddavaram microwatershed of Koyyuru mandal of Visakhapatnam district revealed that soils are low to medium in available nitrogen, phosphorus and potassium and deficient to sufficient in available sulphur. soils of the microwatershed were deficient to sufficient in available Zn and sufficient in available Fe, Cu and Mn.

Keywords: Macronutrients, micronutrients, organic carbon, pH, surface horizon and sub-surface horizon

1. INTRODUCTION

Soil, water and vegetation are the most important natural resources, which are so much interdependent that one cannot be managed efficiently without the other two. Sustainable utilization of these resources involves understanding of various aspects of these resources. Soils are considered as the integral part of the landscape and their characteristics are largely governed by landform on which they are developed (Sharma *et al*., 1997). The deficiency of nutrients directly effects the growth of crops and crop response become poor. Hence, it is necessary to assess the fertility status of soil with the consideration of available nutrients in soil and to recommend the specific nutrients for the proper management of soil. Fertilizing soils to bring all the deficient elements to high levels so as to provide sufficient ionic activity in soil solution for crop uptake is one of the most important considerations for maximization of the crop yield. The assay of soil fertility status is essential for judicious use of fertilizers and assurance of better crop yields.

However, so far, no effort has been made to study the nutrient status of the soils in Doddavaram microwatershed to identify the suitability of the area for various crops. Keeping this in view, the present investigation has been taken to study the physico-chemical and chemical properties in the soils of Doddavaram microwatershed of Koyyuru mandal, Visakhapatnam district for sustainable production.

2. MATERIAL AND METHODS

The study area was Doddavaram microwatershed located in Koyyuru mandal, Visakhapatnam district of Andhra Pradesh which located in between 17° 38' 8.765" to 17° 41' 43.100" of North latitudes and 82° 13' 2.884" to 82° 14' 5.422" of East longitudes with a total geographical area of 2364 ha comprising of 1379.18 ha of cultivable land and 948.82 ha of forest area. The microwatershed area has a sub-humid monsoonic climate with an average annual rainfall of 1265.86 mm, of which 981.28 mm (or 77.52%) of the total was received between July and November, while the mean annual atmospheric temperature was 22.48 °C.

Soil reaction (pH) and soluble salt concentration (EC) were estimated by the procedures outlined by Jackson (1973). The organic carbon content of the soil samples was estimated by Walkley and Black (1934) wet digestion method. Available nitrogen was assessed by the modified alkaline potassium permanganate method (Subbiah and Asija 1956). Available phosphorus in soil was extracted with 0.5 M $NaHCO_3$ of pH 8.5 and measured on a spectrophotometer (Olsen et al. 1954). Available soil potassium was extracted with neutral normal ammonium acetate and measured on flame photometer (Jackson 1973). Available sulphur was estimated by 0.15 % calcium chloride extraction method as outlined by Williams and Steinbergs (1959) and measurement of its concentration in the extracts by turbidimetric procedure using barium chloride (Verma 1977). The available zinc, copper, iron and manganese in soils were extracted by DTPA and measured by atomic absorption spectrophotometer (Lindsay and Norvell 1978).

3. RESULTS AND DISCUSSION

Physico-chemical properties (Table1):

All the pedons of the Doddavaram microwatershed study area were very strongly acidic to slightly alkaline in reaction and pH values of 1:2.5 soil water suspension ranged from 4.58 to 7.82. The significant range of pH in the soils was associated with the nature of the parent material, climate, leaching, presence of Fe, Mn nodules and calcium carbonate. Similar observations were also seen in the central and the eastern parts of Prakasam district in Andhra Pradesh (Sekhar *et al* ., 2014) and in ayucut of Thotapalli reservoir of North Coastal Andhra Pradesh (Himabindu *et al* ., 2018). The soil pH measured with 1*N* KCl (1:2.5) suspension ranged from 4.17 to 6.84. In all horizons of the pedons, the pH of 1*N* KCl was lower than that of water, indicating that negatively charged clay particles predominate over oxide minerals in the soil (Biswas and Budihal, 2007).

The electrical conductivity of soil water extract in watershed soils was ranged from 0.02 to 0.17 dS m^{-1}. The results of the present study indicated that the soils in the microwatershed were non-saline due to excess leaching of salts and free drainage conditions, favoring the removal of released bases by percolating and drainage water. Similar findings were made by Jayaramarao *et al .* (2012) in soils of Srikakulam district, Andhra Pradesh.

The organic carbon content in different horizons of pedons in the watershed ranged from 0.10 to 0.78 per cent, indicating low to high. All the pedons in the microwatershed showed a decreasing trend with depth except pedon 13, which showed an irregular trend with depth. Similar results were reported by Prabhavati *et al .* (2015) in different watersheds of Karnataka and Jyothirmaya *et al .* (2019) in the watershed area of Haryana in North-West India. The surface horizons contained more organic matter than the sub-surface horizons due to the addition of plant residues and farmyard manure to the surface horizons, which led to higher organic carbon content in the surface horizons when compared to the lower horizons. Moreover, this could also be the reason for the decreasing trend in organic carbon with depth that was present in all the pedons.

Macronutrients (Table2):

The available nitrogen ranged from 28.30 to 147.14 mg kg^{-1} soil with mean values of available nitrogen varying from 63.19 to 121.67 mg kg^{-1} soil. Considering 125 mg kg^{-1} as critical level, the available N status was low to medium in the surface and sub-surface soils and a decreasing trend with depth was observed in all the pedons. The cultivation of crops is mainly restricted to the surface horizon (rhizosphere) only, and it was found that relatively the highest available N was in surface horizons and regularly decreased due to the decreasing trend of organic carbon with depth (Kumar and Naidu, 2012). The available phosphorus in all the horizons of the pedons was found to be low (2.19 mg kg^{-1} P_2O_5) to medium (14.78 mg kg^{-1} P_2O_5), considering 10 mg kg^{-1} as the critical level. All the pedons showed a decreasing trend with depth except pedons 12 and 17. The mean value of available phosphorus varied from 5.20 to 11.65 mg kg^{-1} soil. The lower phosphorus content could be attributed to the fixation of released phosphorus by clay minerals and oxides of iron and aluminium (Rani *et al.*, 1992). The comparatively low phosphorus concentrations in sub-surface horizons was caused by clay minerals, iron oxides, and aluminium oxides fixing released phosphorus (Thangasamy *et al .,* 2005 and Arunima *et al* ., 2018).

The available potassium in different soils ranged from 27.63 to 117.44 mg kg^{-1}soil and was found to have low to medium potassium status, considering 58 mg kg^{-1}as a critical limit. The mean value of available potassium varied from 47.67 to 75.99 mg kg^{-1}soil. The pedons 1,3,8,9,10,11,12,13,14,15,16 and 20 exhibited a decreasing trend with depth and the remaining profiles 2,4,5,6,7,17,18 and 19 did not show any definite pattern with change in depth. Low exchangeable potassium status may have been caused by the slow weathering of mica and fixing of liberated potassium (Prakash and Rao, 2002). Increased weathering, release of liable potassium from organic wastes, use of potassic fertilizers, upward translocation of potassium from lower depths and capillary groundwater rise could all be factors contributing to the decreasing trend of available K with depth (Sharma and kumar, 2003 and Basavaraju *et al* ., 2005).

The available sulphur content varied from 1.41 to 20.83 mg kg^{-1} soil and considering 10 mg S kg^{-1} soil as critical value these soils were deficient to sufficient in available sulphur. All the pedons showed a decreasing trend with depth and the mean values of available sulphur ranged from 7.02 to 14.95 mg kg^{-1} soil. The Surface layers contained high available sulphur than sub-surface layers, which could be due to a higher amount of organic matter in surface layers than in sub-surface layers. A significant positive correlation (r = +0.713**) between organic carbon and available sulphur confirmed the above trend. Similar conclusions were reported by Devi *et al .* (2015).

Micronutrients(Table2):

Zinc availability in soil varied from 0.15 to 0.84 mg kg^{-1}. The mean values of the available zinc were between 0.31 and 0.75 mg kg^{-1} soil and all the pedons tend to decrease with depth. According to Lindsay and Norvell (1978), the critical level of zinc is 0.6 mg kg^{-1} soil and the status of available zinc in the study area ranged from deficient to sufficient. The surface horizons of pedons 1,2,9,10,11,13,14,15,16,1718,19 and 20 were sufficient in available zinc, while the pedons 3,4,5,6,7,8 and 12 showed deficient levels in the surface horizons. Moreover, the zinc concentration in the sub-surface horizons was sufficient to deficient. The distribution of available zinc generally decreases as depth increases in all pedons. DTPA-extractable Zn was higher in surface horizons in most pedons and generally declined with depth. With increasing soil depth, the available zinc content showed a decreasing trend, which might be attributed to the declining trends of organic carbon in the soil profiles. Similar findings were made by Kumar and Naidu (2012) in the soils of the Chittoor district.

The available copper was ranged from 0.59 to 3.04 mg kg^{-1} soil. All the pedons showed a decreasing trend with depth and the mean values of available copper varied from 1.25 to 2.44 mg kg^{-1} soil. The surface and sub-surface horizons of all the pedons in the study area of Doddavaram microwatershed were found to be sufficient in available copper (0.59 to 3.04 mg kg^{-1} soil) as all the values were well above the critical limit of 0.2 mg kg^{-1} soil as suggested by Lindsay and Norvell (1978). Similar outcome was obtained by Sarkar *et al .* (2000) and Verma *et al .* (2005) in soils of Madhubani district in Bihar and soils developed on different physiographic units of Fatehgarh Sahib district of Punjab, respectively.

The available iron varied from 8.24 to 29.65 mg kg^{-1} soil. The lowest value of 8.24 mg kg^{-1} soil was observed in the Bt5 horizon of pedon 5, while the highest value of 29.65 mg kg^{-1} soil was noticed in the Ap horizon of pedon 11. All the pedons showed a decreasing trend with depth and the mean value of available iron varied from 12.56 to 22.99 mg kg^{-1} soil. Considering the critical limit of 4.5 mg kg^{-1} soil suggested by Lindsay and Norvell (1978), the soils were sufficient in available iron. The surface horizons contain more Fe than sub-surface horizons. It might be due to organic carbon accumulation in the surface horizons.

Available manganese content varied between 10.25 and 37.62 mg kg^{-1} soil. The lowest value of 10.25 mg kg^{-1} soil was observed in the Bt5 horizon of pedon 7 and the highest value of 37.62 mg kg^{-1} soil was noticed in the Ap horizon of pedon 11. The mean value of available manganese varied from 16.09 to 32.16 mg kg^{-1} soil, while all the pedons exhibited a decreasing trend with depth. The available manganese was sufficient because these values were well above Lindsay and Norvell's (1978) critical limit (1.0 mg kg^{-1}). These observations were in accordance with the findings of Sarkar *et al.* (2000) and Bhaskar *et al.* (2004) in the soils of Bihar and Meghalaya,respectively. The available manganese was almost high in the surface horizons and almost decreased with depth, possibly due to comparatively higher biological activity or organic carbon in the surface horizons. Similar findings were also made by Reddy and Naidu (2016) in soils of the Chennur mandal of the Kadapa district.

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Table 1: Physico-chemical properties of soils

Profile No. & Horizon	Depth (m)	Organic carbon (%)	pH (1: 2.5)			E.C (dSm^{-1})
			H_2O	1*N* KCl	∆ pH	
Pedon 1						
Ap	0.00-0.22	0.63	7.15	6.36	0.79	0.08
Bt1	0.22-0.43	0.44	7.23	6.42	0.81	0.06
Bt2	0.43-0.71	0.26	7.30	6.72	0.58	0.05
Bt3	0.71-1.15	0.13	7.01	6.75	0.26	0.06
Cr	1.15	**Weathered Gneiss**				
Pedon 2						
Ap	0.00-0.16	0.68	7.06	6.40	0.66	0.06
B/A	0.16-0.38	0.46	7.08	6.47	0.61	0.05
Bt1	0.38-0.62	0.42	7.15	6.58	0.57	0.05
Bt2	0.62-1.10+	0.39	7.28	6.59	0.69	0.04
Pedon 3						
Ap	0.00-0.21	0.71	6.40	5.80	0.60	0.04
Bt1	0.21-0.42	0.55	6.35	5.82	0.53	0.03
Bt2	0.42-0.61	0.33	6.25	5.58	0.67	0.03
Bt3	0.61-1.15+	0.21	6.15	5.59	0.56	0.03
Pedon 4						
Ap	0.00-0.22	0.52	5.70	4.98	0.72	0.03
Bt1	0.22-0.43	0.48	5.65	4.92	0.73	0.02
Bt2	0.43-0.64	0.38	5.61	5.08	0.53	0.02
Bt3	0.64-1.10	0.20	5.63	5.15	0.48	0.03
Cr	1.10	**Weathered Gneiss**				
Pedon 5						
Ap	0.00-0.19	0.69	5.50	5.18	0.32	0.03
Bt1	0.19-0.42	0.65	5.37	4.83	0.54	0.03
Bt2	0.42-0.61	0.46	5.32	4.98	0.34	0.02
Bt3	0.61-0.83	0.26	5.44	5.06	0.38	0.02
Bt4	0.83-1.10	0.13	5.55	5.15	0.40	0.02
Bt5	1.10-1.30+	0.13	5.57	5.15	0.42	0.02
Pedon 6						
Ap	0.00-0.21	0.37	4.58	4.17	0.11	0.04
Bt1	0.21-0.54	0.33	5.40	5.16	0.24	0.03
Bt2	0.54-0.72	0.34	5.73	5.30	0.43	0.03
Bt3	0.72-0.92	0.16	5.80	5.25	0.55	0.03
Bt4	0.92-1.10	0.20	5.89	5.24	0.65	0.02
Bt5	1.10-1.50+	0.16	5.90	5.28	0.62	0.02
Pedon 7						
Ap	0.00-0.19	0.34	5.51	5.01	0.50	0.04
Bt1	0.19-0.31	0.27	5.71	5.30	0.41	0.03

Bt2	0.31-0.52	0.20	5.92	5.41	0.51	0.03
Bt3	0.52-0.71	0.19	6.05	5.39	0.66	0.02
Bt4	0.71-1.16	0.18	5.93	5.55	0.38	0.03
Bt5	1.16-1.30+	0.10	6.08	5.39	0.69	0.03
Pedon 8						
Ap	0.00-0.19	0.52	5.92	5.37	0.55	0.04
A1	0.19-0.42	0.40	5.92	5.27	0.65	0.03
A2	0.42-0.60	0.34	5.90	5.55	0.35	0.06
Bt1	0.60-1.18	0.29	6.15	5.54	0.61	0.04
Cr	**Weathered Gneiss**					
Pedon 9						
Ap	0.00-0.18	0.74	7.61	6.40	1.21	0.16
Bw1	0.18-0.41	0.58	7.75	6.37	1.38	0.10
Bw2	0.41-0.62	0.39	7.80	6.41	1.39	0.10
Bw3	0.62-0.80	0.28	7.82	6.84	1.38	0.08
Bw4	0.80-1.20+	0.16	7.80	6.45	1.35	0.07
Pedon10						
Ap	0.00-0.18	0.42	6.96	5.69	1.27	0.05
A1	0.18-0.42	0.33	7.16	5.67	1.49	0.09
A2	0.42-0.60	0.30	7.08	5.96	1.12	0.10
Bt1	0.60-0.80	0.27	7.21	5.92	1.29	0.09
Bt2	0.80-1.20+	0.20	7.24	6.01	1.23	0.08
Pedon 11						
Ap	0.00-0.19	0.55	6.56	6.50	0.06	0.04
A1	0.19-0.39	0.48	6.55	5.85	0.70	0.03
A2	0.39-0.60	0.34	6.54	5.60	0.94	0.03
Bt1	0.60-0.81	0.31	6.56	5.05	1.51	0.03
Bt2	0.81-1.12+	0.21	6.37	4.89	1.48	0.02
Pedon 12						
Ap	0.00-0.22	0.67	5.90	5.11	0.79	0.05
Bt1	0.22-0.41	0.45	5.98	5.30	0.68	0.04
Bt2	0.41-0.61	0.30	6.21	5.28	0.93	0.03
Bt3	0.61-0.82	0.21	6.44	5.26	1.18	0.03
Bt4	0.82-1.20+	0.11	6.41	5.19	1.22	0.03
Pedon 13						
Ap	0.00-0.21	0.45	5.85	4.60	1.25	0.17
Bt1	0.21-0.50	0.36	5.74	4.59	1.15	0.04
Bt2	0.50-0.75	0.30	5.84	4.73	1.11	0.03
Bt3	0.75-0.92	0.32	5.82	4.77	1.05	0.02
Bt4	0.92-1.40+	0.32	5.81	4.73	1.08	0.02
Pedon 14						
Ap	0.00-0.20	0.77	5.87	5.10	0.77	0.03
Bw	0.20-0.42	0.48	5.91	5.16	0.75	0.06

R	0.42		**Hard Weathered Rock**			
Pedon15						
Ap	0.00-0.18	0.75	5.95	5.24	0.71	0.08
Bw	0.18-0.40	0.47	5.84	5.17	0.67	0.06
R	0.40	**Hard Weathered Rock**				
Pedon 16						
Ap	0.00-0.19	0.78	6.25	5.07	1.18	0.04
A1	0.19-0.42	0.70	6.05	4.95	1.10	0.03
Bt1	0.42-0.60	0.48	5.77	5.05	0.72	0.07
Bt2	0.60-0.80	0.34	6.17	5.09	1.08	0.02
Cr	0.80	**Weathered Gneiss**				
Pedon17						
Ap	0.00-0.18	0.62	5.45	4.45	1.00	0.03
AB	0.18-0.34	0.54	5.95	5.40	0.55	0.03
BA	0.34-0.55	0.40	6.30	5.48	0.82	0.03
2Bw1	0.55-0.67	0.27	6.42	5.57	0.85	0.05
2Bw2	0.67-1.10+	0.20	6.55	5.54	1.01	0.03
Pedon 18						
Ap	0.00-0.23	0.70	6.66	4.39	2.27	0.06
AB	0.23-0.45	0.47	6.94	5.23	1.71	0.04
Bt1	0.45-0.69	0.41	7.01	5.24	1.77	0.03
Bt2	0.69-0.88	0.30	6.45	5.24	1.21	0.07
Bt3	0.88-1.20+	0.14	6.66	5.35	1.31	0.03
Pedon 19						
Ap	0.00-0.22	0.72	5.71	5.13	0.58	0.06
Bt1	0.22-0.38	0.45	5.88	5.25	0.63	0.03
Bt2	0.38-0.57	0.27	6.66	5.30	1.36	0.04
Bt3	0.57-0.79	0.26	6.80	5.22	1.58	0.05
Bt4	0.79-1.10+	0.25	7.10	5.24	1.86	0.03
Pedon 20						
Ap	0.00-0.20	0.56	7.01	4.95	2.06	0.07
Bt1	0.20-0.39	0.35	7.11	5.07	2.04	0.08
Bt2	0.39-0.52	0.32	5.88	5.21	0.67	0.05
Bt3	0.52-0.80	0.35	5.70	5.24	0.46	0.03
Cr	0.80	**Weathered Gneiss**				

Table 2: Available Macronutrient and Micronutrent contents of soil

Profile No. & Horizon	Depth (m)	Available macronutrients (mg kg^{-1})				Available Micronutrients (mg kg^{-1})			
		N	P_2O_5	K_2O	S	Zn	Cu	Fe	Mn
Pedon 1									
Ap	0.00-0.22	130.15	11.49	117.44	14.48	0.78	1.66	18.66	26.71
Bt1	0.22-0.43	90.54	6.57	72.54	10.59	0.63	1.35	17.26	18.94
Bt2	0.43-0.71	84.88	5.47	62.18	8.83	0.42	1.17	16.84	19.76
Bt3	0.71-1.15	56.58	4.38	51.81	5.30	0.26	0.85	12.63	16.47
Cr	1.15	**Weathered Gneiss**							
Pedon 2									
Ap	0.00-0.16	118.83	12.59	100.17	13.07	0.84	1.85	19.76	30.27
B/A	0.16-0.38	84.88	9.30	48.36	10.95	0.65	1.30	17.23	28.10
Bt1	0.38-0.62	67.90	6.57	55.27	6.36	0.52	1.09	13.75	25.61
Bt2	0.62-1.10+	50.93	5.47	34.54	3.53	0.33	0.76	10.26	24.22
Pedon 3									
Ap	0.00-0.21	130.15	10.95	96.72	15.89	0.52	2.03	15.35	27.02
Bt1	0.21-0.42	101.85	7.66	55.27	12.71	0.46	1.95	13.36	26.58
Bt2	0.42-0.61	79.22	4.93	51.81	7.77	0.32	1.67	12.28	25.69
Bt3	0.61-1.15+	62.24	3.83	41.45	4.24	0.28	1.32	9.25	22.16
Pedon 4									
Ap	0.00-0.22	113.17	10.40	41.45	17.30	0.51	2.45	18.23	27.09
Bt1	0.22-0.43	90.54	6.02	75.99	14.48	0.42	1.63	15.28	26.81
Bt2	0.43-0.64	67.90	5.47	86.36	11.30	0.39	1.34	13.26	25.57
Bt3	0.64-1.10	45.27	4.38	34.54	7.06	0.27	1.11	10.59	23.28
Cr	1.10	**Weathered Gneiss**							
Pedon 5									
Ap	0.00-0.19	118.83	13.14	72.54	18.71	0.46	1.79	19.65	18.26
Bt1	0.19-0.42	96.19	9.85	79.45	16.24	0.43	1.49	16.55	25.29
Bt2	0.42-0.61	79.22	8.21	44.91	13.07	0.38	1.30	15.28	24.72
Bt3	0.61-0.83	62.24	5.47	58.72	9.89	0.34	1.51	12.26	20.44
Bt4	0.83-1.10	45.27	4.93	62.18	3.88	0.26	1.11	10.31	18.35

Bt5	1.10-1.30+	39.61	3.83	41.45	2.82	0.19	0.59	8.24	13.54
Pedon 6									
Ap	0.00-0.21	101.85	10.40	55.27	19.77	0.45	2.25	26.15	27.12
Bt1	0.21-0.54	73.56	8.76	89.81	18.01	0.39	2.03	22.24	24.93
Bt2	0.54-0.72	67.90	8.21	34.54	14.83	0.35	1.94	19.19	21.32
Bt3	0.72-0.92	56.58	7.12	58.72	11.65	0.28	1.53	16.26	20.56
Bt4	0.92-1.10	50.93	6.57	48.36	9.18	0.22	1.32	12.34	18.26
Bt5	1.10-1.50+	28.30	5.47	38.00	4.59	0.15	0.92	11.28	16.38
Pedon 7									
Ap	0.00-0.19	107.51	9.85	48.36	18.36	0.48	2.33	25.74	28.48
Bt1	0.19-0.31	90.54	8.21	96.72	16.24	0.42	1.62	20.73	24.52
Bt2	0.31-0.52	79.22	7.12	38.00	11.30	0.38	1.31	17.57	22.32
Bt3	0.52-0.71	67.90	6.57	75.99	9.53	0.25	1.26	16.38	15.98
Bt4	0.71-1.16	62.24	5.47	51.81	5.30	0.17	0.97	14.78	12.26
Bt5	1.16-1.30+	39.61	4.38	34.54	4.24	0.15	0.75	11.64	10.25
Pedon 8									
Ap	0.00-0.19	118.83	7.66	69.08	16.95	0.56	2.23	20.95	26.05
A1	0.19-0.42	101.85	6.02	55.27	13.77	0.49	2.10	19.33	22.45
A2	0.42-0.60	73.56	4.93	41.45	9.53	0.36	1.84	15.36	20.28
Bt1	0.60-1.18	56.58	2.74	31.09	4.24	0.28	1.10	12.28	13.48
Cr	1.18	**Weathered Gneiss**							
Pedon 9									
Ap	0.00-0.18	124.49	13.14	75.99	15.89	0.72	2.84	25.07	21.37
Bw1	0.18-0.41	90.54	7.66	58.72	10.24	0.66	2.61	22.36	18.24
Bw2	0.41-0.62	67.90	6.02	44.91	7.77	0.57	2.34	17.82	15.36
Bw3	0.62-0.80	56.58	3.83	38.00	6.00	0.43	2.31	12.94	13.18
Bw4	0.80-1.20+	39.60	2.74	31.09	3.18	0.26	2.12	10.38	12.28
Pedon10									
Ap	0.00-0.18	107.51	9.30	79.45	14.83	0.67	2.03	19.26	32.85
A1	0.18-0.42	96.19	6.57	62.18	13.42	0.53	1.55	15.28	28.35
A2	0.42-0.60	84.88	4.38	48.36	8.83	0.42	1.12	13.76	25.85
Bt1	0.60-0.80	73.56	3.28	41.45	4.94	0.35	0.95	11.56	22.72

Bt2	0.80-1.20+	50.93	2.74	34.54	3.88	0.21	0.71	10.24	15.39
Pedon 11									
Ap	0.00-0.19	124.49	14.23	86.36	14.83	0.68	2.72	29.65	37.62
A1	0.19-0.39	101.85	7.12	48.36	11.30	0.52	2.63	27.40	35.92
A2	0.39-0.60	84.88	7.66	41.45	8.83	0.45	2.31	24.30	33.28
Bt1	0.60-0.81	67.90	6.02	34.54	5.65	0.38	1.49	18.36	29.19
Bt2	0.81-1.12+	45.27	2.74	27.63	2.82	0.26	1.02	15.24	24.81
Pedon 12									
Ap	0.00-0.22	135.80	7.12	65.63	17.66	0.43	2.08	27.35	36.17
Bt1	0.22-0.41	101.85	6.57	58.72	16.24	0.39	2.07	24.32	27.08
Bt2	0.41-0.61	84.88	8.21	51.81	11.30	0.32	2.00	21.56	23.19
Bt3	0.61-0.82	62.24	9.30	44.91	8.83	0.28	1.65	20.48	22.91
Bt4	0.82-1.20+	45.27	3.83	34.54	6.36	0.17	1.13	14.29	21.08
Pedon 13									
Ap	0.00-0.21	107.51	10.40	75.99	18.36	0.72	2.34	20.16	32.35
Bt1	0.21-0.50	84.88	7.66	65.63	14.83	0.63	1.97	19.51	28.76
Bt2	0.50-0.75	67.90	7.12	58.72	12.71	0.54	1.61	17.74	23.24
Bt3	0.75-0.92	56.58	3.83	48.36	9.89	0.42	1.57	15.26	21.35
Bt4	0.92-1.40+	33.95	2.19	38.00	4.94	0.31	1.10	12.28	19.68
Pedon 14									
Ap	0.00-0.20	141.46	9.30	72.54	19.42	0.76	2.84	19.73	32.48
Bw	0.20-0.42	101.85	6.02	51.81	13.77	0.65	1.80	15.32	25.65
R	0.42	**Hard Weathered Rock**							
Pedon15									
Ap	0.00-0.18	147.14	7.66	79.45	20.83	0.81	2.16	17.14	29.85
Bw	0.18-0.40	90.54	6.57	55.27	15.54	0.69	1.43	15.28	20.46
R	0.40	**Hard Weathered Rock**							
Pedon 16									
Ap	0.00-0.19	135.80	7.12	93.26	15.89	0.73	3.04	23.26	27.83
A1	0.19-0.42	118.83	6.02	65.63	13.42	0.62	2.39	21.24	26.36
Bt1	0.42-0.60	84.88	4.38	58.72	9.18	0.43	2.18	16.22	25.05

Bt2	0.60-0.80	56.58	3.28	48.36	3.88	0.29	1.32	12.35	21.16
Cr	0.80	**Weathered Gneiss**							
Pedon17									
Ap	0.00-0.18	118.83	8.21	75.99	19.07	0.66	2.55	18.56	27.69
AB	0.18-0.34	107.51	7.66	51.81	16.95	0.59	2.37	17.44	26.06
BA	0.34-0.55	90.54	8.21	48.36	12.36	0.48	1.56	16.95	24.32
2Bw1	0.55-0.67	84.88	4.38	62.18	10.95	0.34	1.38	14.84	23.66
2Bw2	0.67-1.10+	56.58	2.74	44.91	6.00	0.19	1.26	14.51	19.18
Pedon 18									
Ap	0.00-0.23	130.15	14.78	65.63	12.71	0.62	2.81	21.43	23.71
AB	0.23-0.45	96.19	8.76	72.54	10.24	0.56	2.36	19.26	20.11
Bt1	0.45-0.69	79.22	7.12	79.45	7.42	0.43	2.34	18.88	19.31
Bt2	0.69-0.88	56.58	5.47	41.45	4.24	0.38	2.21	16.25	17.24
Bt3	0.88-1.20+	45.27	3.83	34.54	1.41	0.26	2.15	14.32	13.28
Pedon 19									
Ap	0.00-0.22	135.80	11.49	62.18	18.36	0.68	2.51	18.26	27.87
Bt1	0.22-0.38	101.85	10.40	51.81	15.89	0.55	2.36	17.15	24.24
Bt2	0.38-0.57	90.54	9.30	79.45	8.47	0.51	2.15	15.23	23.19
Bt3	0.57-0.79	62.24	6.57	69.08	5.65	0.42	1.86	13.28	19.16
Bt4	0.79-1.10+	39.61	3.28	38.00	2.82	0.35	1.45	11.35	12.36
Pedon 20									
Ap	0.00-0.20	124.49	9.30	65.63	13.07	0.62	2.52	22.74	31.47
Bt1	0.20-0.39	101.85	6.02	55.27	11.30	0.54	1.98	19.62	28.59
Bt2	0.39-0.52	84.88	3.28	44.91	4.94	0.43	1.93	18.25	21.97
Bt3	0.52-0.80	62.24	2.19	41.45	4.24	0.31	1.39	16.22	18.21
Cr	0.80	**Weathered Gneiss**							