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Chemical Composition and Molar Ratios of Some Coastal Soils of Guntur District, Andhra Pradesh

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ABSTRACT

Soil samples collected from eight profiles representing the sandy and inland black soils in Pedapuluguvaripalem village, Guntur district, A.P. were studied for their chemical composition. The silica content varied from 63.09 to 90.54 per cent and sesquioxide content ranged from 5.35 to 30.41 per cent in different profiles. High silica content was observed in coarse textured soils than in fine textured soils. The alumina and iron oxide contents of the profiles varied from 2.93 to 23.55 per cent and 1.72 to 9.88 per cent, respectively. The calcium oxide content was found to be relatively higher than other oxides varying from 1.06 to 2.97 per cent. The molar ratios and concentrations exhibited the dominance of silica over sesquioxides in all the soils.

Key words : Silica and sesquioxide contents, Silica- sesquioxide molar ratios, Soil composition.

Chemical composition of soils depends on parent material, stage of weathering and climate of the area. For understanding the degree of chemical weathering of a soil, the concept of molar ratios (i.e. % oxide divided by the molecular weight), which research studies have shown to be reliable indices of weathering is an important way of evaluating the reactive loss of different elements during the course of weathering (Jenny, 1941). The soils differ in the contents of extractable iron and aluminum, which is a pointer to the fact that the parent materials from which the soils have been derived have undergone different degrees of weathering. One of the commonly used molar ratios is silica: sesquioxide (SiO_2 : Al_2O_3 +Fe_2O_3)ratio. As a rule, these ratios decrease with weathering. Silica -alumina and silica-sesquioxide molar ratios are also used for expressing the nature of clays. The changes down a profile in the silica-alumina and silica-sesquioxide ratios assist in explaining the development of that profile. In this study an attempt was made to study the chemical composition and molar ratios of the soils of coastal region of Guntur district.

MATERIAL AND METHODS

The study area is a coastal village i.e. Pedapuluguvaripalem in Guntur District of Andhra Pradesh situated between 15^0 95' and 16^0 13' North latitude and 80^0 65' East longitude and was confined to semi-arid to sub-humid climate with mean annual rainfall of 1007.84 mm and mean annual temperature of 28.11^{0}C. Horizon-wise soil samples were collected from representative soil profiles and analyzed for their chemical composition. Acid extract was prepared by digesting the soil with diacid mixture (HNO_3 and $HClO_4$ in 10:4 ratio) until dense white fumes appeared. Then the digested sample was filtered through whatman No 41 filter paper by repeated washing of the silica residue with 0.5M HCl initially and later with glass distilled water and finally diluted to 250 mL (Hesse, 1971). The silica content was determined from the chloride free residue left during the preparation of acid extract which was ignited in a muffle furnace, cooled and weighed to a constant weight. The sesquioxides were determined by taking 100 mL of the acid extract in which the iron and aluminium were precipitated by adding methyl red and ammonium hydroxide (1:1) in the presence of ammonium chloride (1 g). The precipitate was washed free of chlorides, dried, ignited, cooled and weighed to a constant weight. The iron oxides were estimated from acid extract by atomic absorption spectrophotometer, while alumina by deducting iron oxide from sesquioxide content (Hesse, 1971). The calcium and magnesium contents were estimated by Versenate method (Kanwar and Chopra, 1976), whereas the potassium and sodium were estimated by aspirating the acid extract to flame photometer (Jackson, 1973). The phosphorus was determined in acid extract as per the procedure given by Jackson (1973). The results are expressed as oxides.

Table 1. Chemical composition of the soils (% on oven dry basis).

Profile No. & horizon	Depth (m)	SiO_2	R_2O_3	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	P_2O_5
Profile 1 Coarse loamy over clayey, smectite, iso-hyperthermic, Vertic Haplustepts										
Ap	0.00-0.17	88.38	9.02	5.54	3.48	1.26	0.60	0.10	0.25	0.04
2B	0.17-0.33	68.84	25.35	17.68	7.67	2.09	1.41	0.34	0.38	0.06
2Bw1	0.33-0.51	67.82	26.70	17.85	8.85	2.16	1.60	0.39	0.45	0.06
2Bw2	0.51-0.74	66.10	27.35	18.44	8.91	2.20	1.86	0.47	0.46	0.07
2Bw3	0.74-1.00	65.13	27.98	18.10	9.88	2.21	1.90	0.54	0.58	0.07
2Bw4	1.00_+	63.09	28.92	20.03	8.89	2.41	1.98	0.61	0.33	0.05
Profile 2 Coarse loamy,smectitic, iso-hyperthermic, Fluventic Haplustepts										
Ap	0.00-0.14	86.98	8.75	6.49	2.26	1.06	0.21	0.07	0.11	0.04
A2	0.14-0.29	87.16	8.10	5.26	2.84	1.09	0.63	0.13	0.19	0.03
2Bw1	0.29-0.49	74.57	20.72	17.74	2.98	1.95	1.30	0.30	0.38	0.02
2Bw2	0.49-0.72	73.64	21.38	17.57	3.81	2.09	1.41	0.24	0.30	0.01
2BC	0.72-0.96	77.01	17.24	13.30	3.94	1.98	1.12	0.23	0.25	0.02
3C	0.96+	85.33	10.75	7.64	3.11	1.06	0.91	0.2	0.18	0.03
Profile 3 Coarse loamy, smectitic, iso-hyperthermic, Typic Ustipsamments										
Ap	0.00-0.12	86.62	9.98	4.43	5.55	1.09	0.88	0.17	0.18	0.02
AC	0.12-0.29	86.93	9.72	4.75	4.97	1.15	0.78	0.18	0.15	0.07
C1	0.29-0.40	87.08	9.67	6.08	3.59	1.25	0.82	0.19	0.13	0.07
C2	0.40-0.67	87.19	9.23	5.88	3.35	1.72	0.60	0.13	0.12	0.07
C3	0.67+	87.43	9.12	6.87	2.25	1.81	1.20	0.13	0.10	0.06
Profile 4 Fine loamy, smectitic, isohyperthermic, Vertic Haplustepts										
Ap	0.00-0.20	85.28	11.52	8.39	3.13	1.13	0.75	0.15	0.11	0.03
2Bw1	0.20-0.50	73.27	22.51	16.51	6.00	2.15	0.80	0.34	0.75	0.04
2Bw2	0.50-0.71	70.90	23.65	17.29	6.36	2.27	1.12	0.44	0.65	0.04
2Bw3	0.71-0.90	69.41	24.32	21.02	3.30	2.31	1.21	0.46	0.59	0.05
3C1	0.90-0.96	71.39	18.42	15.51	2.91	2.28	0.89	0.37	0.25	0.03
3C2	0.96-1.10	73.27	17.52	16.65	2.87	2.39	0.74	0.38	0.15	0.04
Profile 5 Fine loamy, smectitic, isohyperthermic, Vertic Haplustepts										
Ap	0.00-0.13	63.15	30.41	23.55	6.86	2.97	1.35	0.62	0.19	0.12
B	0.13-0.21	67.49	24.65	16.88	7.77	2.77	2.02	0.81	0.75	0.11
Bw1	0.21-0.45	67.23	25.05	17.08	7.97	2.79	2.23	0.57	0.63	0.06
Bw2	0.45-0.63	67.14	26.01	17.71	8.30	2.81	2.32	0.62	0.65	0.06
2C	0.63-0.95	73.67	18.52	13.51	5.01	2.49	2.02	1.01	0.75	0.05
3C	0.95+	90.54	5.85	3.54	2.31	1.29	0.67	0.54	0.28	0.03
Profile 6 Fine loamy over sand, smectitic, iso-hyperthermic, Typic Haplustepts										
Ap	0.00-0.18	67.24	23.39	17.89	5.50	2.56	1.32	0.32	0.09	0.09
Bw1	0.18-0.34	68.20	22.8	14.48	8.32	2.59	1.41	0.18	0.75	0.07
Bw2	0.34-0.48	69.48	22.27	13.53	8.74	2.79	3.02	0.30	0.68	0.06
2C1	0.48-0.70	84.71	7.90	3.03	4.87	2.51	2.62	0.30	0.53	0.05
2C2	0.70-0.98	85.62	7.25	3.64	3.61	2.23	1.81	0.24	0.36	0.04
2C3	0.98+	87.65	6.12	3.30	2.82	2.02	0.87	0.54	0.18	0.04
Profile 7 Coarse loamy, smectitic, iso-hyperthermic, Typic Ustipsamments										
Ap	0.00-0.13	86.31	8.64	5.29	3.35	1.85	0.71	0.94	0.13	0.03
C1	0.13-0.24	86.73	8.31	4.53	3.78	1.90	0.68	0.83	0.14	0.02
C2	0.24-0.49	87.12	7.92	4.12	3.80	2.17	0.66	0.50	0.35	0.01
C3	0.49-0.68	87.46	7.56	4.81	2.75	2.38	0.63	0.54	0.33	0.02
C4	0.68+	88.19	5.35	3.63	1.72	2.51	0.61	1.31	0.38	0.01
Profile 8 Coarse loamy, smectitic, iso-hyperthermic, Typic Ustipsamments										
Ap	0.00-0.14	76.27	18.52	15.49	3.03	1.81	1.21	1.11	0.28	0.04
C1	0.14-0.22	87.18	8.67	4.57	4.10	1.22	0.84	1.11	0.25	0.03
C2	0.22-0.32	87.56	8.45	4.59	3.86	1.19	0.72	1.02	0.23	0.03
C3	0.32-0.55	88.20	8.12	5.15	2.97	1.14	0.67	0.50	0.19	0.02
C4	0.55-0.76	88.63	7.80	4.11	3.69	1.10	0.54	0.81	0.18	0.04
C5	0.76+	89.13	7.20	2.93	4.27	1.07	0.38	0.81	0.15	0.06

Table 2. Molar concentrations and molar ratios.

Profile No. & horizon.	Depth (m)	Molar Concentrations (% on oven dry basis)				Molar Ratios			
		SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	SiO_2/R_2O_3	SiO_2/Al_2O_3	SiO_2/Fe_2O_3	Al_2O_3/Fe_2O_3
Profile 1 Coarse loamy over clayey, smectite, iso-hyperthermic, Vertic Haplustepts									
Ap	0.00-0.17	1.473	0.076	0.022	0.054	19.37	27.12	67.72	2.50
2B	0.17-0.33	1.147	0.221	0.048	0.173	5.19	6.62	23.93	3.62
2Bw1	0.33-0.51	1.130	0.230	0.055	0.175	4.91	6.46	20.44	3.16
2Bw2	0.51-0.74	1.102	0.236	0.056	0.181	4.66	6.09	19.78	3.25
2Bw3	0.74-1.00	1.086	0.239	0.062	0.177	4.54	6.12	17.58	2.87
2Bw4	1.00_+	1.052	0.252	0.056	0.196	4.17	5.35	18.92	3.53
Profile 2 Coarse loamy,smectitic, iso-hyperthermic, Fluventic Haplustepts									
Ap	0.00-0.14	1.450	0.078	0.014	0.064	18.64	22.78	102.63	4.50
A2	0.14-0.29	1.453	0.069	0.018	0.052	20.96	28.17	81.84	2.91
2Bw1	0.29-0.49	1.243	0.193	0.019	0.174	6.45	7.15	66.73	9.34
2Bw2	0.49-0.72	1.227	0.196	0.024	0.172	6.26	7.13	51.54	7.23
2BC	0.72-0.96	1.284	0.155	0.025	0.130	8.28	9.84	52.12	5.30
3C	0.96+	1.422	0.094	0.019	0.075	15.07	18.99	73.17	3.85
Profile 3 Coarse loamy, smectitic, iso-hyperthermic, Typic Ustipsamments									
Ap	0.00-0.12	1.444	0.078	0.035	0.043	18.48	33.24	41.62	1.25
AC	0.12-0.29	1.449	0.078	0.031	0.047	18.66	31.11	46.64	1.50
C1	0.29-0.40	1.451	0.082	0.022	0.060	17.69	24.35	64.68	2.66
C2	0.40-0.67	1.453	0.079	0.021	0.058	18.49	25.21	69.40	2.75
C3	0.67+	1.457	0.081	0.014	0.067	17.90	21.63	103.62	4.79
Profile 4 Fine loamy, smectitic, isohyperthermic, Vertic Haplustepts									
Ap	0.00-0.20	1.421	0.102	0.020	0.082	13.96	17.28	72.66	4.20
2Bw1	0.20-0.50	1.221	0.199	0.038	0.162	6.13	7.54	32.56	4.32
2Bw2	0.50-0.71	1.182	0.209	0.040	0.170	5.65	6.97	29.73	4.26
2Bw3	0.71-0.90	1.157	0.227	0.021	0.206	5.10	5.61	56.09	9.99
3C1	0.90-0.96	1.304	0.170	0.018	0.152	7.66	8.57	71.69	8.36
3C2	0.96-1.10	1.323	0.162	0.018	0.144	8.19	9.21	73.77	8.01
Profile 5 Fine loamy, smectitic, isohyperthermic, Vertic Haplustepts									
Ap	0.00-0.13	1.053	0.274	0.043	0.231	3.84	4.56	24.55	5.39
B	0.13-0.21	1.125	0.214	0.049	0.165	5.25	6.80	23.16	3.41
Bw1	0.21-0.45	1.121	0.217	0.050	0.167	5.16	6.69	22.49	3.36
Bw2	0.45-0.63	1.119	0.226	0.052	0.174	4.96	6.44	21.57	3.35
2C	0.63-0.95	1.228	0.164	0.031	0.132	7.50	9.27	39.21	4.23
3C	0.95+	1.509	0.049	0.014	0.035	30.71	43.48	104.52	2.40
Profile 6 Fine loamy over sand, smectitic, iso-hyperthermic, Typic Haplustepts									
Ap	0.00-0.18	1.121	0.210	0.034	0.175	5.34	6.39	32.60	5.10
Bw1	0.18-0.34	1.137	0.194	0.052	0.142	5.86	8.01	21.86	2.73
Bw2	0.34-0.48	1.158	0.187	0.055	0.133	6.18	8.73	21.20	2.43
2C1	0.48-0.70	1.412	0.060	0.030	0.030	23.47	47.53	46.38	0.98
2C2	0.70-0.98	1.427	0.058	0.023	0.036	24.50	39.99	63.25	1.58
2C3	0.98+	1.461	0.050	0.018	0.032	29.23	45.15	82.88	1.84
Profile 7 Coarse loamy, smectitic, iso-hyperthermic, Typic Ustipsamments									
Ap	0.00-0.13	1.439	0.073	0.021	0.052	19.76	27.74	68.70	2.48
C1	0.13-0.24	1.446	0.068	0.024	0.044	21.25	32.55	61.19	1.88
C2	0.24-0.49	1.452	0.064	0.024	0.040	22.64	35.95	61.14	1.70
C3	0.49-0.68	1.458	0.064	0.017	0.047	22.65	30.91	84.81	2.74
C4	0.68+	1.470	0.046	0.011	0.036	31.72	41.30	136.73	3.31
Profile 8 Coarse loamy, smectitic, iso-hyperthermic, Typic Ustipsamments									
Ap	0.00-0.14	1.271	0.171	0.019	0.152	7.44	8.37	67.12	8.02
C1	0.14-0.22	1.453	0.070	0.026	0.045	20.63	32.43	56.70	1.75
C2	0.22-0.32	1.459	0.069	0.024	0.045	21.11	32.43	60.49	1.87
C3	0.32-0.55	1.470	0.069	0.019	0.050	21.29	29.11	79.19	2.72
C4	0.55-0.76	1.477	0.063	0.023	0.040	23.32	36.66	64.05	1.75
C5	0.76+	1.486	0.055	0.027	0.029	26.81	51.71	55.66	1.08

RESULTS AND DISCUSSIONS

All the profiles were developed from coastal marine sediments. The profiles were classified under Psamments and Haplustepts at great group level. The total silica content in the soils varied from 63.09 to 90.54 per cent. Chemical composition of the soils revealed that silica content was higher in Psamments than Haplustepts. Profiles with coarser texture showed more silica content as they were dominated by sand. The primary and secondary forms of silica being resistant to decomposition become concentrated in the profile (Beckwith and Reeve, 1963). A decreasing trend with depth was observed in Vertic Haplustept (profile 1), whereas increasing trend was observed in Typic Ustipsamments. The silica content showed positive correlation (r = +0.92) with total sand content. The parent material could be a prime factor contributing to variation in the silica (Somasundaram et al., 2010). The chemical weathering of silicate minerals is predominantly by hydrolysis, when silicic acid and its associated bases are liberated. The semi-arid climate might have resulted in mobilization of released silica, which could have moved upward with salt in Vertic Haplustepts (Sharma and Jha, 1989).

Sesquioxide content ranged from 5.35 to 30.41 per cent. Soils with fine texture showed more sesquioxides due to high amounts of clay as indicated by the positive correlation(r = +0.93) with clay content. Profile 1 exhibited an increasing trend, whereas profile 3 and 7 exhibited a decreasing trend, which can be ascribed to the variations in quantities of clay. Irregular trend was observed in other profiles due to irregular distribution of sand, silt and clay. The alumina content of the profiles varied from 2.93 to 23.55 per cent. Highest value was observed in surface horizon of profile 5, while the lowest value was recorded in profile 8. The alumina content remained lower than silica in all the profiles and decreased down the depth in profiles 6 and 7 while in others it did not follow any specific trend likely due to its relatively immobile nature Among different profiles the iron oxide content varied from 1.72 to 9.88 per cent. The highest value was observed in 2Bw3 horizon of profile 1, whereas lowest value was recorded in lower horizon of profile 7. The values did not follow any particular trend in any of the profiles. In majority of the profiles the Fe_2O_3 distribution was more or less uniform which may be attributed to limited leaching and clay texture (Deshmukh and Bapat, 1993).

Calcium oxide was found to be dominant, while other oxides were comparatively in lower quantities. Calcium oxide content increased with depth in profiles 1, 3, and 7, while a decreasing trend was observed in profile 8. No particular trend was observed in the remaining profiles. The MgO, Na_2O, K_2O and P_2O_5 contents varied from 0.21 to 3.02, 0.07 to 1.31, 0.09 to 0.75 and 0.01 to 0.12 per cent, respectively.

Variations in various oxide contents among the profiles might be due to local factors, parent material, leaching conditions and type of clay minerals. The molar concentration of silica ranging from 1.052 to 1.509 moles was relatively higher than other constituents indicating the siliceous nature of clay.

The SiO_2/R_2O_3, SiO_2/Al_2O_3 and SiO_2/Fe_2O_3 were narrow in heavy textured soils and wide in light textured soils. The ratios were high in light textured soils due to the presence of more silica. The molar ratio SiO_2/Al_2O_3 indicated that SiO_2 content was much higher than Al_2O_3 which might be due to the process of silication operating in these soils. Lesser sesquioxides indicated lesser degree of pedogenic development. The higher SiO_2/R_2O_3 also indicate lesser weathering of soils and the dominance of montmorillonite type of clay.

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