The Andhra Agric. J 69 (3): 416-424, 2022

Elemental composition, molar ratios and pedogenesis of soils in Tekkali mandal of Srikakulam district, Andhra Pradesh

B Sravani, P Gurumurthy, I Usha Rani, A Upendra Rao and D Srinivas

Department of Soil Science and Agricultural Chemistry,
Agricultural College, Naira - 532 185

ABSTRACT

A study on elemental composition and pedogenesis of soils of Tekkali mandal of Srikakulam district was carried out during 2022. The soils of study area were developed from granite-gneiss to calcareous- murrum mixed granite-gneiss parent material. Total silica (SiO_2) of soils ranged from 49.1 to 70.8 percent. Silica content in general decreased with soil depth, while sesquioxides (R_2O_3), alumina (Al_2O_3), iron oxide (Fe_2O_3), CaO, K_2O, Na_2O and MnO were found increasing with depth. The highest value of silica/sesquioxide ratio indicate siliceous nature of soils. The aluminum oxide content of the profiles varied from 15.50 to 22.20 per cent. The highest value was reported in *Thirlangi* profile, whereas the lowest value was recorded in *Naupada* profile. Iron oxide content varied from 3.03 to 8.9 per cent. Iron oxide content showed slight variation within a profiles and greater variation among profiles. The other oxides were in the order of CaO > MgO > K_2O > Na_2O. The molar concentration of silica (SiO_2) ranged from 0.817 to 1.178 moles, and molar concentration of sesquioxide ranged from 0.178 to 0.266 moles. The molar ratio of SiO_2 / R_2O_3 varied from 3.89 to 6.59 in different soil profiles. The SiO_2 / Al_2O_3 ratio varied from 4.71 to 7.26. These wider molar ratios indicate siliceous nature of parent material and dominance of silica among chemical fraction. The profiles examined in the current study showed the chemical index of alteration (CIA) values of the profiles examined varied from 52 to 88. The CIA values decreased with depth in all profiles. The surface horizons P2 and P5 profiles, were classified as very highly weathered. On the other hand, all subsurface horizons of these two profiles were slightly weathered. However, in profiles 1, 3, 4, 6, and 7 the CIA values were between 80 and 90 indicating highly weathered condition of soils. The chemical index of weathering (CIW) values closely followed the trend of CIA values. The bases/R_2O_3 values of all profiles ranged from 0.168 to 1.122 and found increased with soil depth in all the profiles. Relatively higher values of bases/R_2O_3 were found in P2 and P5 indicating base rich character. The weathering index of Parker (WIP) values of the soils formed on calcareous parent material (P_2 and P_5) were between 8.7 and 30.9. The lowest WIP values (6.4 to 11.3) were associated with profiles developed from granite gneiss parent material in uplands (P_1, P_3, P_4, P_6 and P_7). The PIA values ranged from 52 to 88 decreased with the depth in all profiles.

Keywords*: *Elemental composition, Molar ratios, Pedogenesis, Tekkali mandal

Soils are the resultant action of chemical, biochemical and physical weathering processes (pedogenesis) took place on parent material over a period of time. The chemical composition of the soils reflects the land form, climate, parent material and intensity of weathering. Nearly ninety percent of the mineral matter of most of the soils consists of the combined oxides of silicon, aluminium and iron, while the oxides of calcium, magnesium, sodium and potassium together constitute 5 to 7 percent (ISSS, 2012). The elemental composition of soil also reveals the constituent minerals and nutrient supplying capacity of soils. Chemical weathering indices are commonly used to quantitatively evaluate changes caused by chemical weathering in different materials (Birkeland, 1999). The indices are based on the principle that the ratio between concentrations of mobile (e.g. SiO_2, CaO, MgO and Na_2O) and immobile (e.g. Al_2O3, Fe_2O_3 and TiO_2) elements will decrease over time as leaching progresses. However, the weathering of heterogeneous rocks confounds the understanding of the relationship between the weathering index and depth (Dengiz *et al.*, 2013). Different weathering indices like Chemical Index of Alternation (CIA), Chemical Index of Weathering (CIW), Weathering Index of Parker (WIP), Bases/R_2O_3 Ratio, Plagioclase Index of Alteration (PIA) and Vogt's residual index (V) have been successfully applied to understand the pedogensis of soils. The soils of Tekkali mandal in Srikakulam district of Andhra Pradesh developed from granite-gneiss and calcarious murrum combined granite-gneiss were not studied earlier for their elemental composition, molar ratios and pedogenesis.

MATERIAL AND METHODS:

The study area Tekkali mandal of Srikakulam district located between 18^0 12' 820'' to18^0 32' 876'' N latitude and 83^0 29'889'' to 83^0 37' 727'' E longitude, covering 14786 ha and comprises of fifty four revenue villages. The climate belongs to semiarid monsoon type with alternate wet and dry seasons as evidenced by past one decade meteorological data from 2012 to 2021. The average annual rainfall in the area was 927.1 mm, out of which as much as 675 mm (73%) was received during July to November months. The mean annual temperature was 27.45 ^{0}C. A reconnaissance soil survey was conducted in the Tekkali mandal during April to June, 2022 using toposheets of 1: 50,000 scale as per the procedure outlined by AIS&LUS (1970). In the study area soil variation was identified through auger bores, mini pits and road cuts. Soil correlation exercise resulted in identification of seven representative profiles located in Telinelapuram, Thirlangi, Lingalavalasa, Parasurampuram, Ravivalasa, Narsingapalli and Naupada villages. These seven soil profiles were exposed and horizon-wise soil samples were collected. Soil samples were dried in shade and pulvarised with wooden hammer, passed through a 2 mm sieve and the fine earth fraction was analyzed for elemental composition by following standard procedure as described by Hesse (1971) and Jackson (1973). A total of 32 horizon wise soil samples in total were collected to investigate their elemental composition in the laboratory. Molar concentrations and molar ratios were computed from the elemental composition. Weathering indices used (**table 1**) to quantify chemical weathering intensity in the current study included the Chemical Index of Alternation (CIA) (Nesbitt and Young, 1982), Chemical Index of Weathering (CIW) (Harnois, 1988), Weathering Index of Parker (WIP), (Parker, 1970), Bases/R_2O_3 Ratio (Birkeland, 1999), Plagioclase Index of Alteration (Fedo *et al.*, 1995) and Vogt's residual index (Vogt, 1927). Molar ratios were used for calculation of weathering indices.

RESULTS AND DISCUSSION:

Elemental composition

The total silica (SiO_2) content of profiles ranged from 49.1 to 70.8 per cent hence these soils are considered as siliceous in nature and silica content in general decreased with depth. Soils with relatively course texture (P_1, P_3, P_4, P_6 and P_7) are dominated mostly by sand fraction hence showed more silica content. Ramalakshmi *et al.* (2001) also reported similar results in soils of Bapatla-Karlapalem region of Andhrapradesh. Sesquioxide (R_2O_3) content ranged from 19.01 to 29.24 per cent. Profile 6 recorded the highest value of 29.24 in lower horizon and the lowest value of 19.01 per cent was noticed in Ap horizon of profile 1. The variations in sesquioxide content might be due to the physiography, soil drainage and overall pedo-chemical environment (Ramprakash and Seshagirirao, 2002).

The aluminum oxide content of the profiles varied from 15.50 to 22.20 per cent. The highest value was reported in P1 profile, whereas, the lowest value was recorded in P2 profile. Increased trend of alumina with depth was observed in all the profiles which is an indication of more weathering in deeper layers. Aluminum oxide being the major fraction of the sesquioxides, hence followed the pattern of sesquioxides distribution. Similar results were observed by Himabindu *et al.* (2019). Among different profiles the iron oxide content varied from 3.03 to 8.90 per cent. Iron oxide content showed slight variation within a profiles and greater variation among profiles, which is attributed to variation in clay content and chemical composition of primary and secondary minerals. Similar observations were made earlier by Gurumurthy *et al.* (1996) in soils of Giddalur mandal; Ramprakash and Seshagiri Rao (2002) in some selected soils of Krishna district of Andhra Pradesh. The other oxides were in the order of CaO > MgO > K_2O > Na_2O. Calcium oxide content ranged from 1.25 to 8.80 percent and found increasing trend with soil depth. The CaO content was higher in profiles 2 and 5 in which C horizon was found to be calcareous. Similar observations made by Himabindu *et al.* (2019). MgO content ranged from 0.21 to 1.36 percent and increased with soil depth. The magnesium being more soluble than calcium, leached through the profile to lower layers. Because of existing semiarid climate in study area due to limited leaching the basic cation might have accumulated in these soil profiles (Gurumurthy *et al.*, 1996). Potassium oxide, sodium oxide, manganese oxide, copper oxide and zinc oxide of soils of study area ranged from 0.154 to 0.385%, 0.070 to 0.253%, 0.049 to 0.085%, 21 to 53 ppm and 32 to 84 ppm, respectively. Sodium oxide, was found increasing with depth, however potassium oxide, manganese oxide, copper oxide and zinc oxide did not follow any trend with profile depth. Similar observations were reported in some selected soils of Krishna district and Srikakulm district was also reported by Bhaskar *et al.* (2005) and Himabindu (2019).

Molar concentrations

The molar concentration of silica (SiO_2) ranged from 0.817 to 1.178 moles with the highest in *Telineelapuram* profile and lowest in *Ravivalasa* profile. In general a decreasing trend of silica with depth was observed in all the profiles. Molar concentration of sesquioxide ranged from 0.178 to 0.266 moles. The highest value associated with lower horizon of profile 6 and lowest value in surface horizon of profile 2. All the profiles did not follow any specific trend in sesquioxide molar concentration with soil depth. Of all the seven profiles studied the molar concentration of alumina ranged from 0.152 to 0.225 moles with the highest value in profile 6 and lowest value in profile 2. Particular trend was not observed in respect o alumina molar concentration. The molar concentration for iron oxide ranged from 0.019 to 0.052 moles among various profiles and does not follow any specific trend with soil depth. Highest value was recorded in *Naupada* profile, while lowest in *Ravivalasa* profile.

Molar ratios

The molar ratio of SiO_2 / R_2O_3 varied from 3.99 to 6.11 in different soil profiles. The SiO_2 / Al_2O_3 ratio varied from 4.71 to 7.26 in different soil profiles. The SiO_2 / Fe_2O_3 ratio values varied from 17.9 to 54.3. The molar ratio of Al_2O_3 / Fe_2O_3 varied from 3.17 to 8.22 among all the soil profiles. In general, wider SiO_2 / R_2O_3, SiO_2 / Al_2O_3 revealed that these soils are siliceous in nature due to dominance of silica among chemical fraction. The wider SiO_2 / R_2O_3 and SiO_2 / Al_2O_3 ratios could be ascribed to re-silication, a dominant process operating in these profiles. These results are in conformity with those of Ramprakash and Seshagirirao (2002). A fairly high SiO_2 and SiO_2/ Al_2O_3 and SiO_2/R_2O_3 molar ratio in surface horizons indicates more siliceous nature of surface horizons than subsurface horizons and there by advanced stage of pedogenic development (Singh and Mishra, 1994). Relatively less variation in molar ratios of the profiles could be due to variation in chemical composition of parent material. The results are in concurrence with those of Tiwary and Mishra (1993). The molar ratios in general, decreased with increase in soil depth because decreased amount of sand and increased amount of clay with soil depth. The reports of Ramprasad and Seshagiri Rao (2002) and Himabindu *et al.* (2019) supporting the present study.

Weathering indices:

Weathering indices calculated from elemental oxide in molecular concentrations were used to evaluate the vertical changes in a profile. In addition, weathering indices change systematically for soil profiles formed from homogeneous parent rocks with depth. In the current study, six chemical weathering indices were used to evaluate seven profiles under different topographic conditions. Major and micro element concentrations, molar ratios and molar concentrations in the studied profiles are provided in **Tables 2 and 3**.

According to total element analyses the SiO_2 content in all profiles decreased with depth (range of 49.1 to 70.8%) and that $A_{l2}O_3$ values varied from 15.7 to 21.9 %. SiO_2 strongly resists weathering because it is mainly contained in quartz minerals. In contrast, Al_2O_3 is mainly less resistant to weathering because it is contained in the clay minerals; a high content of Al_2O_3 indicates a high content of clay minerals (Shan *et al.*, 2010). The highest amount of

Fe_2O_3 (8.90 %) was in profile 7. In regions where the parent materials are mostly calcareous murrum, elevated concentrations of CaO and MgO were seen in the soils. The CaO content in these soils (P_2 and P_5) range from 1.5 to 8.8%.

Weathering indices of soil profiles of the study are presented in Table 4. The CIA index is based on the progressive removal of soluble cations (e.g. Ca, Na, and K) from minerals during chemical weathering, and it reflects the proportion of primary and secondary minerals in the bulk sample. Generally, rocks from the upper crust and un-weathered igneous rocks have CIA values of near about 50, whereas the soils and sediments derived from intensely weathered rocks, and containing residual clay minerals such as kaolinite and/or gibbsite, have CIA values approaching 100 (Fedo *et al*., 1995; Ozaytekin *et al*., 2012).

The profiles examined in the current study showed the CIA values ranged from 52 to 88. The highest and the lowest CIA values were in the A and C horizons of the profile 3 and profile 5, respectively. The CIA values decreased with depth in all profiles. In other words, the parent materials of all profiles had the lowest CIA values of all layers. Nesbitt and Young (1982) classified the CIA values as very slightly weathered (50 to 60), slightly weathered (60 to 70), moderately weathered (70 to 80), highly weathered (80 to 90), and extremely weathered (90 to100).

When the CIA classification was applied in the current study, the surface horizons P2 and P5 profiles were classified as highly weathered. On the other hand surface horizons of these two profiles were slight to moderately weathered. However, in profiles 1, 3, 4, 6, and 7 the CIA values were between 80 to 90 indicating highly weatherd soils. Harnois (1988) proposed the Chemical Index of Weathering (CIW) which modified CIA by excluding K_2O from assessments. Because the CIW does not account for the aluminium associated with K-feldspar, it may generate very high values for K-feldspar- rich rocks, whether they are chemically weathered or not (Fedo *et al*.,1995). CIW values closely followed the trend of CIA values.

In the present study, the CIW values ranged between 50.0 and 88.0 and tended to decrease with depth in all profiles. The value of CIW increased with weathering. If the classification for CIA is performed for CIW as well, it is evident that all the profiles developed on different parent material are in similar classes in terms of CIW values. This result indicates that the CIW and CIA indices display similar behavior for the different parent material.

The bases/R_2O_3 values of all profiles ranged from 0.168 to 1.007 and were found to increase with soil depth in all the profiles. Similar trend also were observed in bases/ Al_2O_3 values. Relatively higher values of bases/R_2O_3 and bases/ Al_2O_3 were recorded in P2 and P5 indicating base rich character.

Parker's Weathering Index (WIP) is used to evaluate the intensity of the weathering of silicate minerals, based upon the proportion of alkali and alkaline earth elements in the products of weathering. The WIP also takes into account some individual mobilities, namely sodium, potassium, magnesium and calcium, on the basis of their bond strengths with oxygen (Parker, 1970). According to the definition of WIP, smaller WIP values indicate stronger chemical weathering, which is opposite to the manner in which CIA values are generated. This index has been suggested to be most appropriate for application to weathering profiles on heterogeneous parent rocks and is most likely not applicable to highly weathered soils, because the assessment only includes highly mobile alkali and alkaline elements (Price and Vebel, 2003). In the present study, the WIP values of the soils formed on calcareous parent material (P_2 and P_5) were between 8.7 and 30.9. The lowest WIP values (6.4 to 11.3) were associated with profiles developed from granite gneiss parent material in uplands (P_1, P_3, P_4, P_6 and P_7).

There are two explanations for this phenomenon. Firstly, it means that the weathering process is more intense in low elevation soils (P_2 and P_5). Secondly, with time, the soil derived from the parent material diverges progressively from the parent material under the influence of the pedogenic process. In terms of parent material, the profile that developed on granite-gneiss parent material showed relatively high weathering (P_1, P_3, P_4, P_6 and P_7), with the CIA index varying between 82.0 and 88.0 and tending to fluctuate slightly with depth in all profiles. The upper horizons of soil profiles are more weathered than lower horizons as evidenced by decreasing trends of CIA values with soil depth.

Fedo et al. (1995), proposed the Plagioclase Index of Alteration (PIA) as an alternative to the CIW. Because plagioclase is abundant in silicate clay and dissolves relatively rapidly, the PIA may be used when plagioclase weathering needs to be monitored. In the present study, the PIA values ranged from 52 to 88 and decreased with the depth in all profiles.

CONCLUSION:

Elemental composition and molar ratios of the soils depends on parent material, climate and intensity of weathering. The present study provided information on total concentration of nutrient elements like Si, Al, Fe, Ca, Mg, K, Mn, Cu and Zn. Molar concentration and molar ratios help in understanding the nature of minerals and stage of weathering in soils of Tekkali mandal in Srikakulam district of Andhra Pradesh. This study clearly showed that catena and climatic conditions strongly affect the soil chemical and morphological properties, either directly or indirectly, in the local area. These results were supported by the application of the chemical weathering indices (pedogenesis), namely CIA, CIW, Base/R_2O_3 (Al_2O_3 + Fe_2O_3 is sesquioxide or R_2O_3) and PIA. In this study, chemical weathering indices of soil profiles developed on calcareous parent material (profile 2 and 5) and granite gneiss parent material (profile 1,3,4,6 and 7) in different topographical positions showed varied pedogenic indices. The elemental composition of the profiles had variation, and the weathering indices determined with the use of geochemical characteristics show variation among profiles, indicate that the profiles show different intensities of weathering.

Table 1 Different indices of chemical weathering

Index	Formula	Reference
Weathering index of Parker (WIP)	$WIP = \left(\frac{2Na_2O}{0.35} + \frac{MgO}{0.9} + \frac{2K_2O}{0.25} + \frac{CaO}{0.7}\right) \times 100$	Parker (1970)
Vogt's Residual Index (V)	$V = \frac{Al_2O_3 + K_2O}{MgO + CaO + Na_2O}$	Vogt (1927)
Chemical Index of Alteration (CIA)	$CIA = \frac{Al_2O_3}{Al_2O_3 + CaO + Na_2O + K_2O} \times 100$	Nesbitt and Yound (1982)
Chemical Index of weathering (CIW)	$CIW = \frac{Al_2O_3}{Al_2O_3 + CaO + Na_2O} \times 100$	Harnois (1988)
Plagioclase Index of Alteration (PIA)	$PIA = \frac{Al_2O_3 - K_2O}{Al_2O3 + CaO + Na_2O - K_2O} \times 100$	Fedo et al. (1995)
Bases/R_2O_3 Ratio	$(CaO+MgO+Na_2O+K_2O) / (Al_2O_3 + Fe_2O_3)$	Birkeland (1999)

LITERATURE CITED:

All India Soil and Land Use Survey (AIS&LUS) 1970. *Soil Survey Manual*, All India Soil and Land Use Survey, IARI, NewDelhi. pp.1-63.

Bhaskar B P, Baruah U, Vadivelu S Butte P S 2005. Characterization of soils of Brahmaputra valley in Jorhat district of Assam. *Journal of the Indian Society of Soil Science*. 52 (3): 3 -10.

Birkeland P W 1999. *Soils and Geomorphology*, Third edition. New York, Oxford University Press. 430 pp.

Dengiz O, Saðlam M, Özaytekin H H and Baskan O 2013. Weathering rates and some physico-chemical characteristics of soils developed on a calcic toposequences. *Carpathian Journal of Earth and Environmental Sciences* 8(2); 13–24.

Fedo C M, Nesbitt H W, Young G M 1995. Unraveling the effects of potassium metasomatism in sedimentary rocks and paleosols with implications for paleoweathering conditions and provenance. *Geology* 23(10): 921–924.

Table 2 : Chemical composition of the soils (oxide forms of Si, Al, Fe, Ca, Mg, K, Na, Mn, Cu and Zn)

Profile No. & Horizon	Depth (m)	Chemical composition										
		SiO_2	R_2O_3	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	MnO	CuO	ZnO
		%									ppm	
P1. Telinelapuram soil profile		**SiO_2**	**R_2O_3**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**K_2O**	**Na_2O**	**MnO**	**CuO**	**ZnO**
Ap	0.00-0.22	70.8	23.01	18.2	4.81	1.25	0.32	0.29	0.118	0.077	53	84
Bw1	0.22-0.34	66.3	22.96	18.6	4.36	1.25	0.38	0.27	0.138	0.067	50	82
Bw2	0.34-0.55	70.5	22.72	16.8	5.92	1.5	0.49	0.27	0.153	0.061	48	78
Bw3	0.55-0.88	63.1	28.04	21.9	6.14	1.76	0.6	0.3	0.126	0.055	44	75
C	0.88-1.02+	61.6	27.03	22.2	4.83	1.85	0.85	0.27	0.159	0.066	42	73
P2. Thirlangi soil profile												
Ap	0.00-0.16	65.2	19.41	15.5	3.91	2.2	0.65	0.21	0.238	0.062	41	61
Bw1	0.16-0.28	62.1	20.94	17.9	3.04	4.9	0.65	0.21	0.253	0.085	39	56
Bw2	0.28-0.47	58.3	21.6	19.2	4.1	5.3	0.93	0.24	0.226	0.073	36	52
Bw3	0.47-0.72	55.8	21.33	20.5	3.03	5.5	0.8	0.29	0.226	0.063	34	48
Ck	0.72-0.97+	56.3	21.51	20.5	3.51	8.8	1.36	0.29	0.24	0.082	30	45
P3. Lingalavalasa soil profile												
Ap	0.00- 0.15	68	27.43	19.8	7.63	1.34	0.21	0.19	0.081	0.049	34	54
Bt1	0.15-0.34	69.1	26.41	20.1	6.31	1.83	0.33	0.2	0.095	0.052	30	50
Bt2	0.34-0.50	61.6	25.84	19.8	6.04	2.26	0.42	0.19	0.103	0.068	28	42
Bt3	0.50-0.70	66.1	29.05	21.9	7.15	2.25	0.56	0.22	0.122	0.065	25	37
Bt4	0.07- 0.90+	70	25.7	18.1	7.6	1.83	0.61	0.18	0.097	0.059	22	34
P4. Parasurampuram soil profile												
Ap	0.00-0.12	70.5	22.72	16.8	5.92	1.5	0.49	0.27	0.153	0.061	48	78
A1	0.12-0.24	63.1	28.04	21.9	6.14	1.76	0.6	0.3	0.126	0.055	44	75
A2	0.24-0.34	57.6	23.03	18.2	4.83	1.85	0.85	0.27	0.159	0.066	42	73
C	0.34-0.74+	52.6	24.01	18.9	5.11	1.7	0.96	0.39	0.114	0.068	44	72
P5. Ravivalasa soil profile												
Ap	0.00-0.14	61.2	20.1	16.6	3.5	1.5	0.82	0.19	0.106	0.05	51	81
Bw1	0.14-0.28	59.6	19.7	16.6	3.1	2.5	0.89	0.16	0.096	0.06	49	76
Bw2	0.28-0.52	55.2	22.5	18.9	3.6	4.7	1.28	0.24	0.122	0.054	47	69
Bw3	0.52-0.72	52.6	22.01	18.9	3.11	4	1.35	0.19	0.114	0.068	44	72
Ck	0.72-0.94+	49.1	23.03	19.5	3.53	8.5	1.35	0.27	0.149	0.072	41	65
P6. Narsingapalli soil profile												
Ap	0.00-0.21	68.6	25.84	19.8	6.04	1.56	0.42	0.19	0.103	0.068	28	42
Bt1	0.21-0.43	66.1	29.05	21.9	7.15	1.67	0.56	0.24	0.122	0.065	25	37
Bt2	0.43-0.77	70	25.7	18.1	7.6	1.83	0.61	0.28	0.097	0.059	22	34
Bt3	0.77-0.94+	65.8	29.24	21.9	7.34	1.98	0.69	0.23	0.118	0.075	21	32
P7. Naupada soil profile												
Ap	0.00-0.23	67.1	23.3	15.7	7.6	1.45	0.8	0.15	0.098	0.084	43	70
Bw1	0.23-0.45	64.5	24.7	17.1	7.6	1.65	0.85	0.19	0.07	0.072	41	62
Bw2	0.45-0.60	64.5	25.1	16.8	8.3	1.87	0.75	0.27	0.151	0.06	34	56
Bw2	0.60-0.92+	60	27.2	18.3	8.9	1.65	0.85	0.25	0.137	0.071	38	47

Table 3 : Molar concentrations and molar ratios of silica, sesquioxides, alumina oxides, iron oxides, calcium oxides, magnesium oxides, potassium oxides and sodium oxides in soils

Profile No. & Horizon	**Depth (m)**	**Molar concentrations (moles)**								**Molar ratios**					
		SiO_2	**R_2O_3**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**K_2O**	**Na_2O**	**SiO_2/R_2O_3**	**SiO_2/Al_2O_3**	**SiO_2/Fe_2O_3**	**Al_2O_3/Fe_2O_3**	**Bases/R_2O_3**	**Bases/Al_2O_3**
P1. Telinelapuram soil profile															
Ap	0.00-0.22	1.18	0.21	0.178	0.03	0.02	0.01	0.003	0.002	5.6	6.6	39.1	5.92	0.168	0.198
Bw1	0.22-0.34	1.1	0.21	0.182	0.027	0.02	0.01	0.003	0.002	5.25	6.05	40.4	6.68	0.176	0.202
Bw2	0.34-0.55	1.17	0.21	0.165	0.037	0.03	0.01	0.003	0.003	5.65	7.12	31.7	4.44	0.213	0.269
Bw3	0.55-0.88	1.05	0.26	0.215	0.038	0.03	0.02	0.003	0.002	4.1	4.89	27.3	5.58	0.201	0.24
C	0.88-1.02+	1.03	0.25	0.218	0.03	0.03	0.02	0.003	0.003	4.15	4.71	33.9	7.2	0.241	0.274
P2. Thirlangi soil profile															
Ap	0.00-0.16	1.08	0.18	0.152	0.024	0.04	0.02	0.002	0.004	6.11	7.14	44.3	6.21	0.347	0.405
Bw1	0.16-0.28	1.03	0.19	0.175	0.019	0.09	0.02	0.002	0.004	5.4	5.89	54.3	9.22	0.574	0.627
Bw2	0.28-0.47	0.97	0.2	0.172	0.026	0.1	0.02	0.003	0.004	4.91	5.65	37.8	6.68	0.628	0.723
Bw3	0.47-0.72	0.93	0.2	0.179	0.019	0.1	0.02	0.003	0.004	4.76	5.18	49	9.46	0.64	0.696
Ck	0.72-0.97+	0.94	0.2	0.176	0.022	0.16	0.03	0.003	0.004	4.76	5.31	42.6	8.03	1.007	1.122
P3. Lingalavalasa soil profile															
Ap	0.00- 0.15	1.13	0.25	0.194	0.048	0.02	0.01	0.002	0.001	4.51	5.83	23.7	4.06	0.13	0.168
Bt1	0.15-0.34	1.15	0.24	0.197	0.04	0.03	0.01	0.002	0.002	4.76	5.84	29.1	4.99	0.184	0.226
Bt2	0.34-0.50	1.03	0.24	0.194	0.038	0.04	0.01	0.002	0.002	4.34	5.28	27.1	5.13	0.231	0.281
Bt3	0.50-0.70	1.1	0.27	0.215	0.045	0.04	0.01	0.002	0.002	4.14	5.12	24.6	4.8	0.22	0.272
Bt4	0.07- 0.90+	1.17	0.24	0.177	0.048	0.03	0.02	0.002	0.002	4.96	6.57	24.5	3.73	0.219	0.29
P4. Parasurampuram soil profile															
Ap	0.00-0.12	1.17	0.21	0.165	0.037	0.03	0.01	0.003	0.003	5.65	7.12	31.7	4.44	0.213	0.269
A1	0.12-0.24	1.05	0.26	0.215	0.038	0.03	0.02	0.003	0.002	4.1	4.89	27.3	5.58	0.201	0.24
A2	0.24-0.34	0.96	0.21	0.178	0.03	0.03	0.02	0.003	0.003	4.55	5.37	31.7	5.9	0.283	0.335
C	0.34-0.74+	0.88	0.22	0.185	0.032	0.03	0.02	0.004	0.002	3.99	4.72	27.4	5.79	0.274	0.325
P5. Ravivalasa soil profile															
Ap	0.00-0.14	1.02	0.18	0.163	0.022	0.03	0.02	0.002	0.002	5.54	6.26	46.5	7.43	0.278	0.314
Bw1	0.14-0.28	0.99	0.18	0.163	0.019	0.05	0.02	0.002	0.002	5.51	6.1	51.1	8.38	0.389	0.431
Bw2	0.28-0.52	0.92	0.21	0.185	0.023	0.08	0.03	0.003	0.002	4.46	4.96	40.8	8.22	0.585	0.65
Bw3	0.52-0.72	0.88	0.2	0.185	0.019	0.07	0.03	0.002	0.002	4.35	4.72	45	9.51	0.541	0.588
Ck	0.72-0.94+	0.82	0.19	0.172	0.022	0.15	0.03	0.003	0.002	4.25	4.76	37	7.76	0.992	1.112
P6. Narsingapalli soil profile															
Ap	0.00-0.21	1.14	0.24	0.194	0.038	0.03	0.01	0.002	0.002	4.83	5.88	30.2	5.13	0.178	0.217
Bt1	0.21-0.43	1.1	0.27	0.225	0.045	0.03	0.01	0.003	0.002	4.14	5.12	24.6	4.8	0.182	0.225
Bt2	0.43-0.77	1.17	0.24	0.177	0.048	0.03	0.02	0.003	0.002	4.96	6.57	24.5	3.73	0.223	0.295
Bt3	0.77-0.94+	1.1	0.27	0.215	0.046	0.04	0.02	0.002	0.002	4.1	5.1	23.8	4.67	0.213	0.265
P7.Naupada soil profile															
Ap	0.00-0.23	1.12	0.21	0.154	0.048	0.03	0.02	0.002	0.002	5.24	7.26	23.5	3.23	0.23	0.319
Bw1	0.23-0.45	1.07	0.23	0.168	0.048	0.03	0.02	0.002	0.001	4.75	6.4	22.6	3.52	0.238	0.321
Bw2	0.45-0.60	1.07	0.23	0.165	0.052	0.03	0.02	0.003	0.002	4.68	6.52	20.7	3.17	0.25	0.348
Bw2	0.60-0.92+	1	0.25	0.179	0.056	0.03	0.02	0.003	0.002	4.01	5.57	17.9	3.22	0.223	0.31

Table 4 : Weathering indices of different soil profiles of Tekkali mandal of Andhra Pradesh

Profile No. & Horizon	Depth (m)	Weathering Indices					
		WIP	V	CIA	CIW	PIA	Bases/R_2O_3
1. Telinelapuram soil profile							
Ap	0.00-0.22	7.6	5.63	87	88	88	0.168
Bw1	0.22-0.34	7.8	5.44	87	88	88	0.176
Bw2	0.34-0.55	8.8	4.04	84	85	85	0.213
Bw3	0.55-0.88	9.8	4.50	85	87	86	0.201
C	0.88-1.02+	10.8	3.88	85	86	86	0.241
2. Thirlangi soil profile							
Ap	0.00-0.16	11.4	2.60	77	78	78	0.347
Bw1	0.16-0.28	18.4	1.65	65	66	65	0.574
Bw2	0.28-0.47	20.2	1.43	63	64	63	0.628
Bw3	0.47-0.72	20.8	1.50	63	64	63	0.640
Ck	0.72-0.97+	30.9	0.92	52	52	52	1.007
3. Lingalavalasa soil profile							
Ap	0.00- 0.15	6.4	6.44	88	88	88	0.130
Bt1	0.15-0.34	8.1	4.69	84	85	85	0.184
Bt2	0.34-0.50	9.5	3.74	81	82	82	0.231
Bt3	0.50-0.70	10.2	3.86	83	84	83	0.220
Bt4	0.07- 0.90+	8.8	3.62	83	84	84	0.219
4. Parasurampuram soil profile							
Ap	0.00-0.12	8.8	4.04	84	85	85	0.213
A1	0.12-0.24	9.8	4.50	85	87	86	0.201
A2	0.24-0.34	10.8	3.19	82	83	83	0.283
C	0.34-0.74+	11.3	3.37	84	85	85	0.274
5. Ravivalasa soil profile							
Ap	0.00-0.14	8.7	3.36	84	85	85	0.278
Bw1	0.14-0.28	11.1	2.40	77	78	78	0.389
Bw2	0.28-0.52	18.7	1.59	68	68	68	0.585
Bw3	0.52-0.72	16.6	1.75	71	72	71	0.541
Ck	0.72-0.94+	29.1	0.93	52	53	52	0.992
6. Narsingapalli soil profile							
Ap	0.00-0.21	7.7	4.90	86	87	87	0.178
Bt1	0.21-0.43	8.9	4.74	86	87	87	0.182
Bt2	0.43-0.77	9.6	3.64	83	84	84	0.223
Bt3	0.77-0.94+	10.0	3.98	84	85	85	0.213
7.Naupada soil profile							
Ap	0.00-0.23	8.1	3.28	84	85	85	0.230
Bw1	0.23-0.45	8.8	3.27	84	85	84	0.238
Bw2	0.45-0.60	10.5	3.07	81	82	82	0.250
Bw2	0.60-0.92+	10.0	3.44	84	85	85	0.223

Gurumurthy P, Seeshagiri Rao M, Bhanuprasad V and Pillai R N 1996. The elemental composition amd molar ratios of soils of Giddalur mandla of Andhrapradesh. *The Andhra Agricultural Journal*. 43: 216-217.

Harnois L 1988. The CIW index: A new chemical index of weathering. *Sedimentary Geology*. 55 (3- 4): 319- 322.

Hesse P R 1971. *A Text Book pf Soil Chemical Analysis*. John Murry Ltd. London.

Himabindu K 2019. Taxonomic studies of soils of Thotapalli ayacut area of North coastal Andhra Pradesh. MSc.(Ag.) Thesis submitted to Acharya N.G. Ranga Agricultural university, Lam, Guntur.

Himabindu K, Gurumurthy P and Prasad PRK 2019. Elemental composition and molar ratios of soils of Thotapalli ayacut area of north coastal Andhra Pradesh. *Journal of Research ANGRAU*

Indian Society of Soil Science (ISSS) 2012. *Fundamentals of Soil Science*. 3rd ed. Indian Society of Soil Science, IARI, New Delhi. Pp.209.

Jackson M L 1973. *Soil Chemical Analysis*. Oxford IBH Publishing Company. Bombay.

Nesbitt Y W and Young G M 1982. Early Proterozoic climates and plate motions inferred from major element chemistry of lutites. *Nature*. 299: 715-717.

Ozaytekin H H, Mutlu H H and Dedeoglu M 2012. Soil formation on a calcic chronosequence of ancient Lake Konya in Central Anatolia, Turkey. *Journal of African Earth Science*. 76: 66-74.

Parker A 1970. An index of weathering for silicate rocks. *Geological Magazine* 107(6): 501-504.

Price J R and Velbel M A 2003. Chemical weathering indices applied to weathering profiles developed on heterogeneous felsic metamorphic parent rocks. *Chemical Geology*. 202(3-4): 397-416,

Ramalakshmi Ch S, Seshagirirao M and Bhanuprasad V 2001. Horizon-wise chemical composition of Haplustepts, Haplusterts and Ustipsamments of Bapatla-Kalapalem region of Guntur district of Andhra Pradesh. *The Andhra Agricultural Journal*. 48: 111-113.

Ramprakash T and Seshagirirao M 2002. Characterization and classification of some soils in a part of Krishna district, Andhra Pradesh. *The Andhra Agricultural Journal*. 49 (3&4): 228-236

Shan H M, Liang H C, Peng S X, Longe A A and Zhou A G 2010. Effects of water-saturation and water-loss processes on composition and structure variations of landslide, Three Gorges reservoir, China. In: *Water- Rock Interaction*. Birkle, P., Torres- Alvarado, I. S. (Eds.). CRC Press, New York, USA. pp. 921-924,

SinghV N and Mishr B B 1994. Sodiumization of some Alfisols in topo-sequences occurring in Indogangetic plain of Bihar. *Journal of the Indian Society of Soil Science*. 42 : 626-633

Tiwary R and Mishra B B 1993. Mineralogy of fine sand fractions of red, yellow and black soils of Rajmahal Trap of Bihar. *Journal of the Indian Society of Soil Science.* 41: 807-809.

Vogt T 1927. Sulitjelmafeltets geologi og petrografi. *Norges Geologiske Undersokelse* 121: 1-560 (In Norwegian with English Abstract).

Received on 27.05.2022 and Revised on 13.09.2022