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Research article

THE MORPHOLOGICAL FEATURES OF MICA AND CHLORITE MINERALS IN FINE SAND FRACTION IN SOME FOREST SOILS IN SULAYMANIYAH GOVERNORATE, KURDISTAN

Shuela M. Sheikh-Abdullah[a], and Salman Kh. Essa[b]

[a]Soil and Water Sciences Department, Faculty of Agriculture Sciences, University of Sulaimani, Bakrajo, Kurdistan
[b]Soil Science Department, College of Agriculture, Baghdad University, Baghdad, Iraq

ABSTRACT: This study was conducted to investigate the morphological features of mica and chlorite minerals in fine sand fraction in some forest soils. Soil profiles were taken from seven different sites of forest soils. Which include Khalakan-Pine, Dukan-Oak, Bakhy-bakhteyare-Pine, Goizha-Cypress and Goizha-Olive. Near each above sites, a reference site of soil was dug and they had the same above properties, but are abandoned soils. Soil samples were analyzed for some physical, chemical and mineralogical properties in the soils. The following results were obtained and can be summarized as follows: Results of chemical analysis were exhibited that the pH values for studied soils were ranged between moderate slightly acidic to alkali (6.62-8.36). The results of electrical conductivity (EC) indicated that all studied soils were non-saline, and the value ranged between (0.13-2.07 $dS.m^{-1}$). Amount of calcium carbonate equivalent indicated that the studied soils were calcareous to extremely calcareous soils and the amounts of total and active $CaCO_3$ were ranged between (50-495 $g.kg^{-1}$) and (10-225 $g.kg^{-1}$) respectively. As well as the results showed a decrease in content of organic matters with depth in all studied soils. The results of four forms of K in soils: soluble, exchangeable, Non-exchangeable, and mineral were (0.0014-0.0595), (0.40–1.51), (0.02–1.66), and (17.83–38.72) Cmol kg^{-1} respectively. The change in morphological features of fine sand fraction due to weathering by using optical microscope was investigated and the results showed that the grains of these minerals from individual soil horizons had different colors, those from the surface horizons were have a dark brownish spots, presumable due to staining by organic matter, those from (B) horizon have a yellowish grey-to yellowish brown spots, and those from the (C) horizon were sometimes grey, similar to the parent rocks. In general, almost the grains of chlorite were kept up their green color with depth in all studied pedons, while the surface of these grains in top soil were stained by dark brownish to dark spots, due to partial oxidation of chlorite minerals at the surface soil horizons. The optical microscope examination indicated that mica grains generally occurred as thick particles with different stages of layer separation. They were weathered with layer separations and bending at their edges. However, in control pedons, weak layer separation at the edge was observed.
Key words: Mica, Chlorite, Minerals, Morphology, Forest Soils

INTRODUCTION

The mineralogy of the parent material has an impact on clay mineralogy of soil. As weathering proceeds, the clay content increases as a result of physical and chemical alteration of primary minerals. With further chemical changes, transformation may take place within the clay fraction of the soil. The type of clay minerals formed depends on the climatic conditions and the chemical environment within the soil [1]. The soil mineralogy and weathering stages are two important phenomena governing host of physicochemical soil characteristics and thereof having a central role in the management of the (semi-) natural forested ecosystems [2 &3]. The knowledge of the minerals and their transformations help in understanding the distribution of forest types and their biogeochemistry. It is of great aid in formulating and adopting the success of the necessary silivicultural practices [4]. Micaceous minerals or micas are one of the most frequent components of the earth´s crust. They form ~ 4 % of igneous rocks, an even greater proportion of metamorphic rocks and ~ 50 % or more of sedimentary rocks [5]. Yet, several studies have shown that forest is very efficient in recycling major nutrients. Other elements, such as Si, Fe, and Al, are also recycled by the forest, and this can play a major role in soil genesis [6 &7]; this is supported by the observations of [8] showed that vegetation increases rock weathering rates. The aims of this study are to i: study the morphological features of mica and chlorite minerals in fine sand fraction in forest soil and ii: quantitative determination and distribution of different clay minerals in soil horizons.

MATERIALS AND METHODS

Sample Collection

Soil profiles ditches were dug down to the C horizon. A total of 7 sites were investigated. The profile 1 and 5 cultivated with Pine, the profile 2 was cultivated with Oak, the profile 4 cultivated with Cypress, Profile 6 cultivated with Olive, and profiles 3 and 7 was uncultivated. Total 43 soil samples were collected according to Field book for describing and sampling soils (2002), and composite soil samples were air dried and passed through 2 mm sieve. After that soil samples were stored in plastic bags prior to use.

Laboratory Analyses

Physico-chemical analyses:

Air-dried samples were gently crushed, to completely pass through a 2-mm sieve and analysis was undertaken using this fine earth. Some physico-chemical properties of whole soils were determined. The particle size distribution was determined according to international pipette method as described in [9]. All samples were pre-treated with H_2O_2 to oxidize any organic matter. Soil pH [9], EC [9], Saturation percentage (paste method) [10], Total calcium carbonate equivalent [11], and Active Calcium carbonate [12]. Organic matter in the soils was determined using the Walkley and Black wet digestion method [13].

RESULTS AND DISCUSSIONS

Physical and chemical properties

Some of the physical and chemical properties of the 7 profiles are presented in Tables 1. Results indicated that the range of pH values was between (6.62-8.36), these values of pH reflecting that the reaction of all pedons was around moderate alkali to slightly acidic, due to effect of calcareous parent material of these soils. Results of particle size distribution in (Table 1) showed that in general the amount of clay in all pedons is at its maximum in the B horizon. The pattern of clay distribution decrease with depth then increases in B horizon then decrease in C horizon.[14] pointed that this type of clay distribution with depth may be due to the effect of different types of processes mainly pedogenic and to some extent to geomorphic processes. Increased of clay in surface horizon of some pedons may be due to the effect of geomorphic processes specially erosion of fine fractions from surrounding upland soils and deposition of materials on low plan soils causing to increase clay content in the surface horizon of these pedons. From the results of particle size distribution (Table 1), it is obvious that the texture of studied soils was ranged from clay loam to silty clay loam. Results of Electrical conductivity (EC) indicate that all studied soils were non-saline. The amounts of total and active $CaCO_3$ were ranged between (50-495g.kg^{-1}) and (10-225g.kg^{-1}) respectively. The high content of $CaCO_3$ reflected a calcareous nature of studied soils. The amounts of total and active $CaCO_3$ were increased with depth in all studied pedons, reflect calcareous parent material of these soils. The amount of total organic matter in studied soil samples ranged between 2.44 and 46.64 g. kg^{-1}. These results indicated that the amount of total organic matter was higher in the soil surface and decrease with depth; this is due to the accumulation of high amount of plant residuals at the upper part of soil.

Forms of potassium in studied soils:

The amounts of soluble, exchangeable, Non-exchangeable, mineral, and total potassium of studied soil pedons are shown in Table (2).

Soluble potassium:

Table (2) shows that the amount of soluble potassium arrange between (0.0014-0.0595 Cmol.Kg^{-1}), The proportion of soluble potassium was 0.3982 % of total and 6.46 %of non-exchangeable potassium. These results agree with [15 & 16], who studied some Iraqi soils. In general these values were lower than critical value (0.50 Cmol.Kg^{-1}) according to international potash institute [17]. These results indicate that these soils were highly affected by precipitation and leaching of potassium.

Exchangeable potassium:

Table (2) shows that the amount of exchangeable potassium ranged between 0.40 and 1.51 Cmol.Kg^{-1}, These values were above the critical value of exchangeable potassium found by [18]. Also results showed that the amount of exchangeable potassium was higher in surface horizons comparing with sub-surface horizons in all soil locations, which may be due to the accumulation of organic matter. In addition, the results showed that the highest value of exchangeable potassium was found at surface horizons of oak forest pedones. These data indicate the effect of tree species and their biodegradation, and is a good reason to expect a strong link between organic matter quality and the amount, mobility of elements and also their speciation in the solid phase. The generally accepted theory suggests that a close link between humus chemistry and soil contents of elements exists for many pedogenetic processes. We, therefore, used the opportunity that arose from the changes in organic matter chemistry observed in [19 & 20] studied to further examine potential of plant residues change on soil chemistry and clay mineralogy. [21] found that the chemistry of forest litters was differ greatly between tree species, and oak tree litters have high content of potassium compared to pine litters.

Non-échangeable potassium:

Table (2) shows that the amount of non-exchangeable potassium arrange between 0.02 and 1.66 Cmol. kg^{-1}, the highest amount was founded in (A) horizon of olive forest pedon at Gwezha. In this study we considered the amount of non-exchangeable potassium in predict the release rate of potassium from mica minerals in studied soils, because it's more realable form in representing release rate comparing with soluble and exchangeable forms, which are easy leached forms. In general, it appeared clearly that the largest amount of non-exchangeable potassium was in upper part of the studied soils. This phenomenon has been observed for soil minerals weathering [22].

Table 1: Particle size distribution and some chemical properties in the studied soil pedons.

Profile No.	Horizon	Depth (cm)	soil particles g.kg^{-1}			O.M. (g.kg^{-1})	pH	EC (dS.m^{-1})	$CaCO_3$ (g.kg^{-}	
			sand	Silt	clay				Total	Active
1	A	0-17	305.	302.0	392.4	36.26	7.36	2.07	365	66.5
	B_{k1}	17-34	215.	306.1	478.3	16.52	7.87	0.66	235	57.5
	B_{k2}	34-55	205.	305.9	488.2	12.49	7.81	0.57	195	48.5
	B_{k3}	55-78	211.	370.0	418.5	5.48	7.58	0.42	165	60.0
	B_{k4}	78-89	285.	345.9	368.9	4.26	7.37	0.31	190	60.0
	C_k	89+	339.	349.1	311.3	3.66	7.88	0.29	240	95.0
2	A	0-25	114.	445.9	440.0	46.64	7.61	1.06	115	150.0
	B_{k1}	25-40	101.	401.6	496.9	14.01	7.70	0.34	280	207.5
	B_{k2}	40-56	92.9	462.4	444.7	4.87	7.35	0.24	285	200.0
	B_{k3}	56-83	90.9	480.6	428.5	4.81	7.50	0.20	400	225.0
	B_{k4}	83-103	108.	454.5	437.5	3.05	7.57	0.20	435	222.5
	C_k	103+	103.	465.9	430.5	2.44	8.02	0.13	495	220.0
3	A	0-20	138.	360.9	500.7	37.16	7.45	0.89	145	110.0
	B_{k1}	20-30	141.	387.6	470.7	21.93	7.70	0.41	200	85.0
	B_{k2}	30-49	170.	392.1	437.6	12.79	7.94	0.39	300	107.5
	B_{k3}	49-70	190.	421.8	387.5	7.92	7.73	0.27	360	182.5
	C_{k1}	70-92	181.	444.1	374.4	4.57	7.34	0.33	370	145.0
	C_{k2}	92+	176.	464.2	359.7	4.26	7.73	0.37	310	157.5
4	A	0-15	158.	476.7	364.6	21.53	7.71	0.29	134	80.0
	B_{k1}	15-33	98.1	408.1	493.8	15.36	7.94	0.41	375	80.0
	B_{k2}	33-53	81.3	411.1	507.6	10.18	7.82	0.38	480	120.0
	C_{k1}	53-83	98.9	477.3	423.8	9.74	7.77	0.25	400	120.0
	C_{k2}	83-110	79.4	531.3	389.3	8.19	7.74	0.20	425	110.0
	C_{k3}	110+	96.6	516.5	386.9	7.69	8.01	0.20	395	120.0
5	A	0-17	49.7	321.2	629.1	35.20	7.97	0.56	416	142.5
	B_{k1}	17-30	103.	345.3	551.7	22.70	8.28	0.35	310	122.5
	B_{k2}	30-65	147.	393.5	459.0	14.50	8.15	0.30	355	142.5
	B_{k3}	65-93	140.	473.1	386.7	11.30	8.36	0.27	425	144.5
	C_k	93+	158.	467.0	374.3	8.20	8.31	0.22	365	120.0
6	A1	0-15	27.2	459.5	513.3	22.70	8.07	0.23	50	15.0
	A2	15-30	81.3	554.7	364.0	20.10	7.99	0.21	55	20.0
	Bk1	30-47	91.3	567.5	341.2	15.10	7.96	0.22	120	55.0
	Bk2	47-62	103.	596.0	301.0	12.60	7.77	0.28	235	105.0
	Bk3	62-89	103.	609.0	288.0	9.40	7.70	0.24	285	110.0
	Ck1	89-115	103.	645.6	251.2	6.90	7.96	0.25	280	95.0
	Ck2	115-130	113.	652.8	233.4	5.00	8.00	0.20	260	105.0
7	A	0-12	67.1	527.4	405.5	16.83	7.90	0.20	195	60.0
	Bk1	12-33	101.	586.5	312.3	10.70	7.74	0.17	315	110.0
	Bk2	33-52	108.	610.7	281.3	12.94	7.70	0.16	295	110.0
	Bk3	52-80	81.3	534.7	384.0	10.82	7.57	0.22	287	80.0
	B_{k4}	80-99	101.	617.4	281.2	13.17	7.69	0.17	282	85.0
	C_{k1}	99-120	113.	643.7	243.2	8.95	7.53	0.15	315	85.0
	C_{k2}	120-	103.	645.7	251.2	6.71	7.81	0.17	300	10.0

Table 2: Different forms of potassium in the studied soil pedon.

Pedon No.	Location and plant cover	Horizone	different form of potassium ($Cmol.kg^{-1}$)				
			Soluble	exchangeable	Non-exchangeable	Mineral	Total
1	Khalakan-Pine	A	0.0595	1.38	0.42	26.24	28.10
		B_{k1}	0.0035	0.64	0.90	33.82	35.37
		B_{k2}	0.0046	0.83	0.66	34.86	36.35
		B_{k3}	0.0033	0.64	0.74	35.48	36.88
		B_{k4}	0.0023	0.52	0.69	32.06	33.28
		C_k	0.0027	0.64	0.47	28.13	29.25
2	Dukan-Oak	A	0.0483	1.51	0.90	26.98	29.46
		B_{k1}	0.0017	0.58	0.29	25.18	26.07
		B_{k2}	0.0022	0.52	0.05	23.11	23.68
		B_{k3}	0.0014	0.40	0.06	21.57	22.04
		B_{k4}	0.0017	0.40	0.03	18.49	18.93
		C_k	0.0017	0.40	0.02	17.83	18.26
3	Dukan-control	A	0.0147	1.24	1.43	30.53	33.23
		B_{k1}	0.0028	0.83	0.81	29.72	31.36
		B_{k2}	0.0031	0.64	0.43	26.83	27.91
		B_{k3}	0.0017	0.58	0.19	24.83	25.61
		C_{k1}	0.0026	0.58	0.25	24.17	25.01
		C_{k2}	0.0017	0.40	0.28	23.28	23.97
4	Goizha-cypress	A	0.0038	0.95	1.43	36.70	39.09
		B_{k1}	0.0027	0.58	0.92	34.05	35.56
		B_{k2}	0.0014	0.52	0.46	30.69	31.68
		C_{k1}	0.0028	0.68	0.15	30.36	31.20
		C_{k2}	0.0031	0.46	0.23	30.40	31.10
		C_{k3}	0.0037	0.46	0.18	30.90	31.55
5	Bakhy bakhtyare-Pine	A	0.0115	1.31	1.31	28.07	30.71
		B_{k1}	0.0058	1.13	0.98	28.56	30.68
		B_{k2}	0.0035	0.70	1.39	26.91	29.02
		B_{k3}	0.0015	0.52	0.33	26.91	27.77
		C_k	0.0018	0.52	0.45	29.30	30.28
6	Goizha-Olive	A_1	0.0028	0.71	1.66	38.30	40.68
		A_2	0.0016	0.52	1.41	38.72	40.66
		B_{k1}	0.0016	0.58	1.19	37.16	38.94
		B_{k2}	0.0014	0.58	0.71	34.52	35.82
		B_{k3}	0.0015	0.52	0.51	33.74	34.77
		C_{k1}	0.0017	0.52	0.49	33.06	34.08
		C_{k2}	0.0015	0.65	0.61	34.83	36.09
7	Goizha-control	A	0.0015	0.89	1.24	34.34	36.48
		B_{k1}	0.0015	0.71	0.37	31.73	32.81
		B_{k2}	0.0031	0.71	0.64	32.83	34.19
		B_{k3}	0.0015	0.65	0.80	31.70	33.15
		B_{k4}	0.0014	0.65	0.34	30.46	31.45
		C_{k1}	0.0016	0.58	0.32	28.82	29.74
		C_{k2}	0.0016	0.58	0.45	27.90	28.93

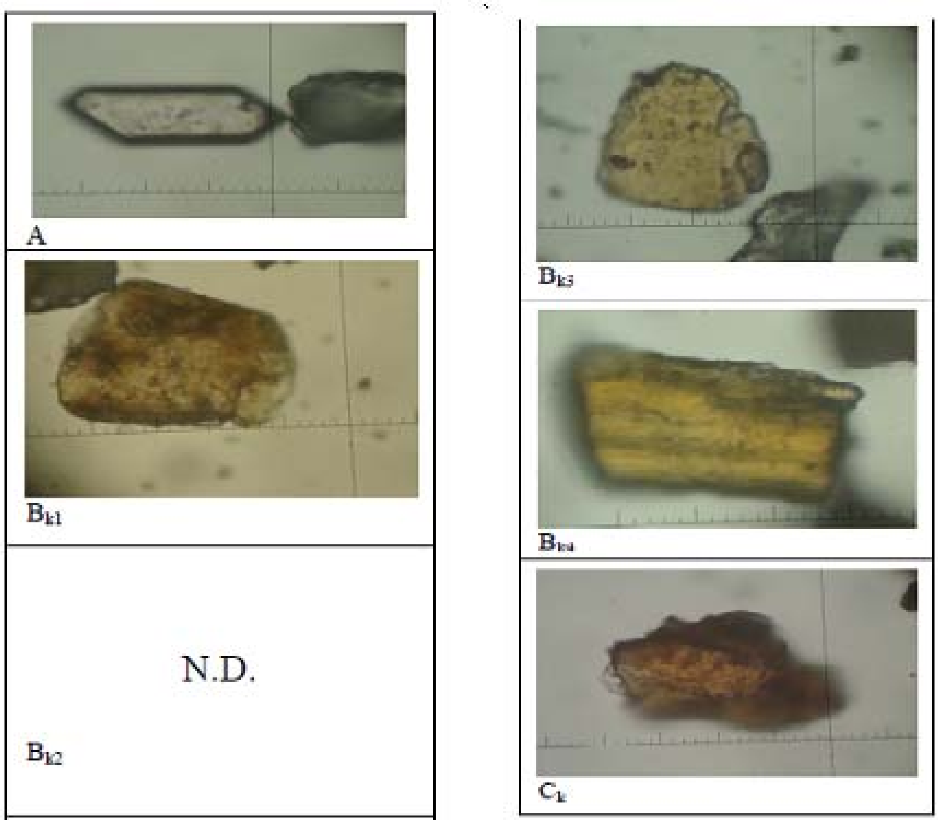

Figure 1: vertical distribution of Chlorite mineral in sand particle separation for Pine forest / Khalakan

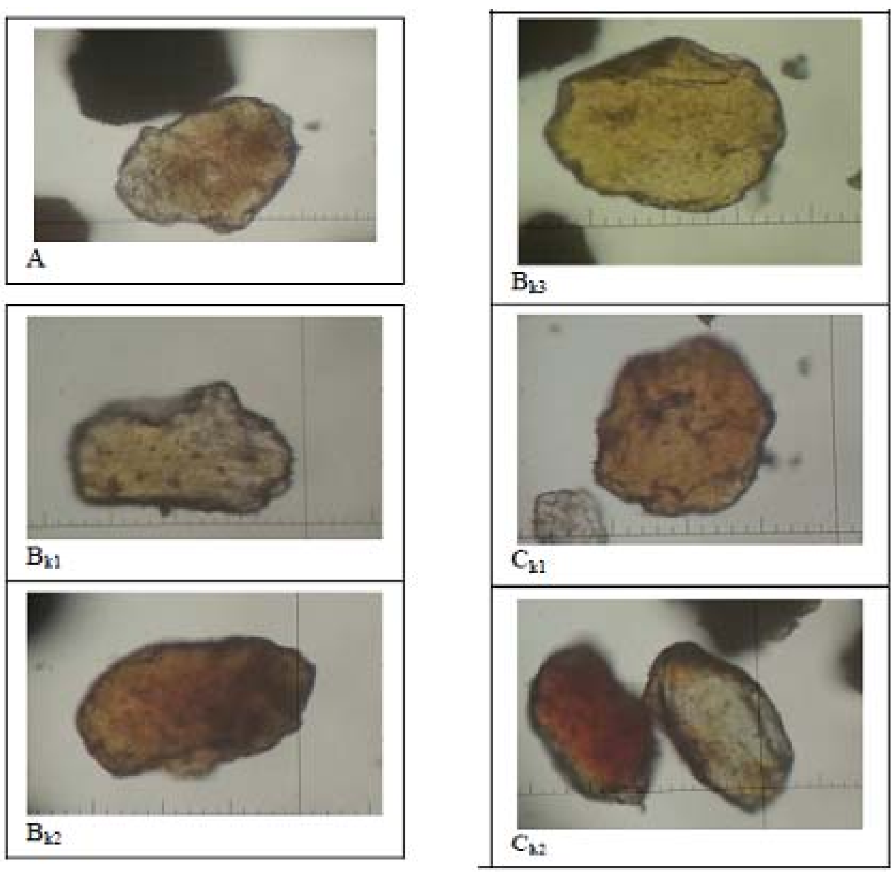

Figure 2: vertical distribution of Chlorite mineral in sand particle separation for control / Khalakan

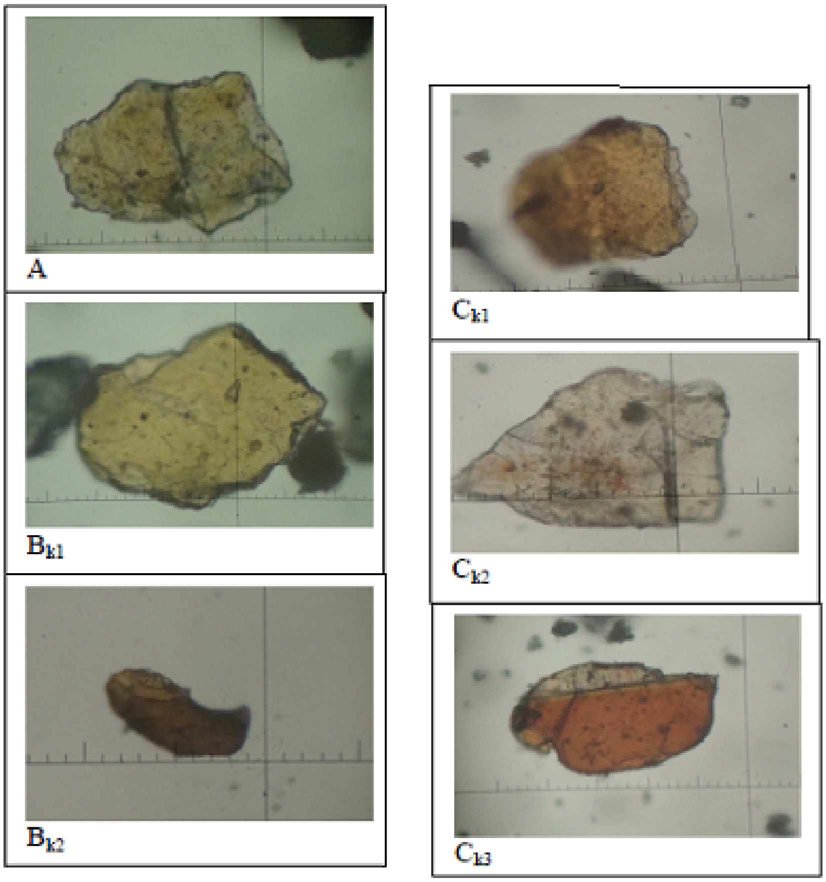

Figure 3: vertical distribution of Biotite mineral in sand particle separation for Cypress forest / Goizha

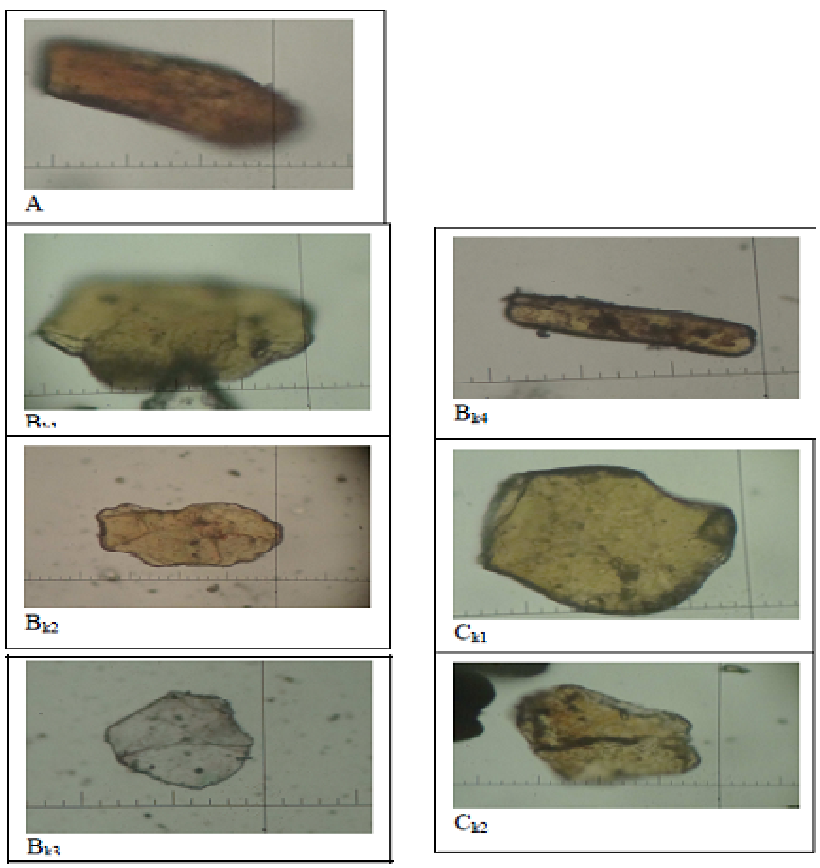

Figure 4: vertical distribution of Biotite mineral in sand particle separation for Control / Goizha

Morphological features of sand fraction in studied soils:

The morphological features of mica minerals and chlorite in fine sand fraction were studied by using optical microscope. There are some minerals in these soils as mica (Muscovite and Biotite), chlorite grains, and smectite minerals. Results in Figures (1- 4) show that the grains of these minerals from individual soil horizons have different colours; those from the surface horizons have dark brownish spots, presumable due to staining by organic matter; those from (B) horizon have yellowish grey-to yellowish brown spots, and those from the (C) horizon are sometimes grey, similar to the parent rocks. In general, almost the grains of chlorite kept up their green color with depth in all studied pedons, while the surface of these grains in top soil were stained by dark brownish to dark spots, due to partial oxidation of chlorite minerals at the surface soil horizons. The staining spots differ in shape and size, probably due to the nature of the organic residuals, which differs according to the types of forest trees. These findings agrees with [20] who found that the rate of organic residuals decomposition is affected by the types of forest trees, and reflect on the rate of minerals weathering and their morphological features. Results in Figures (1 and 2) show that yellowish grey to yellowish brown spots with different shapes and sizes are observed on the surface of chlorite grains. Those selected from (B) horizons, are presumable due to staining by Fe-oxides. The difference in spots color may be related to the crystallization state of Fe-oxides, while differences in shape and size mainly depends on rate of transformation and deposition of these oxides through soil pedons, such as the type of plant covering, and complexations between Fe and humic acids. No change in the colour of the chlorite grains with depth, Figures (1 and 2), have been found in all studied pedons. This can be attributed to the little exposed to weathering effect [23]. Supporting these findings, results in Figures (1 and 2) shows no change in size of chlorite grains throughout individual pedon; but there are differences between pedons due to the surrounding conditions of each pedon. From these results, it seems that the weathering process does not have any effects on the size of chlorite grains, but it reflects on their morphological features. In fact the weathering effects are restricted to the surface of the grains. Results in Figures (3 and 4) show that mica grains exhibit same morphological features (with some exception) as chlorite grains, such as staining by dark-brownish spots on their surface at (A) horizon, and yellowish brown spots at (B) horizon. As mentioned above, these spots are due to staining by organic matter and iron oxides respectively. The optical microscope examination indicated that mica grains generally occur as thick particles with different stages of layer separation. They are weathered with layer separations and bending at their edges Fig (3). However, in control pedons, weak layer separation at the edge is observed Fig (4) possibly due to alteration prior to pedogenesis. These observations indicate that the weathering of mica minerals is almost inhibited in these pedons. A similar observation has been made by [24] in soils of India. Despite this, major layer separation in mica is observed in forest pedons Fig (3). These features indicate the replacement of interlayer K of mica at the edges of these grains, and this leads to formation of 2:1 expansible minerals [25]. In order to confirm the feasibility of K release from interlayer of mica at the edges of these grains in soil environments towards the formation of 2:1 expansible minerals, results in Table (2) show that the soluble and exchangeable K in forest pedons are higher than that of control pedons. This observation further supports the evidence that K is released from weathering edges of mica grains in these soils. Furthermore optical microscop examination indicates that the roughness of the surfaces of mica grains, Fig (3), increases at surface horizons of forest pedons. Roughness intensity also varies with site (e.g. samples from Goizha-olive show less roughness than samples from Khalakan, and Goizha-cypress). The differences in morphological features of these grains between studied sites are due to the difference in tree species. [26] Found that tree species is an important factor for test-minerals weathering dynamics; the dissolution is higher under conifers (Norway spruce and Scots pine) than under hardwoods (Oaks and beech). The difference in tree species effects is due to more acidic characteristics of soils under Goizha-olive soil and compared to Khalakan, and Goizha-cypress pedons. All of these findings imply that there may be bio-physico-chemical processes in forest pedons involving organic residuals-microbe associations operating at mineral surfaces to enhance weathering of minerals. These findings agree with [24], results in Figures (1 - 4) show that mica grains are more affected by weathering process than chlorite grains in all forest pedons. This indicates that the mica grains are more readily attacked by weathering than that of chlorite. These finding agrees with [27], who found that using a dilute fulvic acid (0.025%) taken 22 year to dissolve 1 g of Fe-chlorite and 7.2 year to dissolve 1 g of biotite, and conclude that the biotite structure was more readily attacked by organic acids than that of chlorite.

CONCLUSIONS

1. Morphological features of mineral grains (mica and chlorite) show that there are bio-physico-chemical processes in all forest pedons involving organic residuals microbe associations operating at mineral surfaces that enhance weathering of minerals.
2. Results show that the accumulation of plant residuals in the surface horizons of forest pedons play a big role in mica weathering, active pedogenetic state, and high release rate of K^+.

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