Comparison between Mineralogical Properties of Oak Forest and Un-Cultivated Soils in Iraqi Kurdistan Region

Abstract

This study was conducted to identify the mineralogical properties of oak forest and uncultivated soils at 12 locations in the Iraqi Kurdistan region, which included (Brifca, Gara, and Matin) in Duhok governorate, (Awagrd, Bilah, and Malakan) in Erbil governorate, (Badawan, Bardanga, and Chwarta) in Sulaimani Governorate and (Bakhakon, Hawar, and Sartak) in Halabja governorate. Clay minerals were identified from X-ray diffraction data and peaks. Peak height is used as a rough indicator of the relative abundance of minerals. In general, the expansion of 14°A to 17°A in the ethylene glycol treatment was not detected because measuring started at 5θ so that's why we cannot differentiate between Chlorite and Smectite in that treatment. Swelling chlorite was the dominant mineral in these soils. While the miner clay minerals at those locations were Kaolinite. Mica was identified at all locations, while the dominant type of mica in forest soils was Muscovite, which was obtained from 6 sites, and Mica Biotite was obtained from 4 sites. In uncultivated sites, both types of mica were recorded at 5 sites.

Keywords: *Forest Soils, Un-cultivated soils, Clay minerals, Chlorite*

I. Introduction

The climate of the Kurdistan Region is characterized by extraordinary conditions, with an expansive temperature distinction between day and night and between winter and summer. In summer, the temperature comes to exceed 45ºC within the day at the southern boundaries of the three governorates, whereas within the northern edges it goes down well underneath 20ºC to approximately 15ºC. Because of that, the climate of the Kurdistan region has been classified as semi-arid continental, which is to say hot and dry in summer and cold and rainy in winter. Spring and autumn are humid in comparison to summer and winter [1].

Forest soils in the north of Iraq are usually characterized by being shallow with some deep soils in the plains and valleys area. Forests are usually grown on non-covered rocks penetrated with some forest trees roots which lead to the weathering of parent materials. So, the characteristics of such soils are highly dependent on the nature of the parent material consistent directly [2].

The plant cover, especially trees, has a great effect on soil chemical, mineralogical, physical, and biological properties of the soil. On the other hand types of forest trees had a significant effect on most of the soil characteristics. The properties of oak forest soils are differing from the soil properties of pine forest soils, and cypress forest soils as mentioned by Sheikh-Abdullah [3].

Nutrients required for plant growth other than nitrogen and sometimes sulfur is initially supplied by chemical dissolution of primary minerals in the process known as weathering. vascular plants should accelerate weathering more than the activity of any likely pre-existing primitive terrestrial organisms such as algae and lichens, because of the much greater contact area between minerals and the huge mass of fine roots of the higher plants and because of plants much faster growth and internal storage of rock weathering derived cations [4, 5].

Al-Jaff [6] mentioned that the transformation process of mica mineral to 2:1 expandable mineral in the rhizosphere was exceeded than in bulk soil. In general potassium release from mica, the structure was affected by pH, Oxygen, and microorganisms' activity [7].

There are numerous investigations about studying chemical and mineralogical properties of forest soils conducted by [3, 8-11] but none of them included a special type of forest and they didn't cover different topographical locations for these reasons this investigation was selected to study the mineralogical properties of oak forest soils and comparing them to un-cultivated soils from Gara in Dohuk to Sartak in Halabja.

II. Materials and method

This investigation was conducted from 1/7/2016 to 20/12/2018. Before soil sampling, several trips were made to identify the representative sites. The trips emphasis done to select the suitable and representative Oak forests and un-cultivated soils on one hand and to cover a wide spectrum of soil properties, on the other hand, For this purpose, 12 sites were selected in the Kurdistan region at each site two locations were selected, one of them was oak forest soil and the second one was un-cultivated soil, The total soil samples were 48 samples, collected according to field trips for laboratory analysis as shown from Table I and Fig. 1. Soil samples were air-dried and passed through a 2mm sieve. Clay minerals were identified by X-Ray diffraction, the soil samples were prepared depending on the following steps.

1) Removal of soluble salts by distilled water according to Kunze and Dixon [12].

2) Carbonate minerals were removed by (NaOAc – at pH = 5) as described by Kunze and Dixon [12].

3) Removal of organic matter by (NaOCl 14%), according to Anderson [13].

4) Free oxides were removed by (Sodium citrate $Na_3C_6H_5$, Sodium bicarbonate $NaHCO_3$, and Sodium dithionate $Na_2S_2O_4$) using the method of Mehra and Jackson [14].

TABLE I. Shows geographical coordinates of the sites from which the soil samples were taken

Governorat	*Location*	*Latitude*	*Longitude*	*Altitude*
Duhok	Gara	37°01'40.24'	43°20'04.91'	1193
	Matin	37°04'51.73'	43°15'58.30'	955
	Brifca	36°48'32.89'	43°10'42.19'	778
Sulaimani	Bardanga	36°22'14.45'	44°44'56.71'	927
	Badawan	36°06'18.99'	44°44'16.64'	676
	Chwarta	35°42'42.40'	45°35'33.03'	1204
Hawler	Awagrd	36°13'34.36'	44°28'15.17'	903
	Bilah	36°50'55.76'	44°04'35.76'	511
	Malakan	36°28'24.60'	44°33'44.40'	1202
Halabja	Bakhako	35°15'43.05'	46°06'34.75'	1143
	Hawar	35°09'51.03'	46°06'27.42'	1134
	Sartak	34°56'25.55'	45°46'43.32'	1195

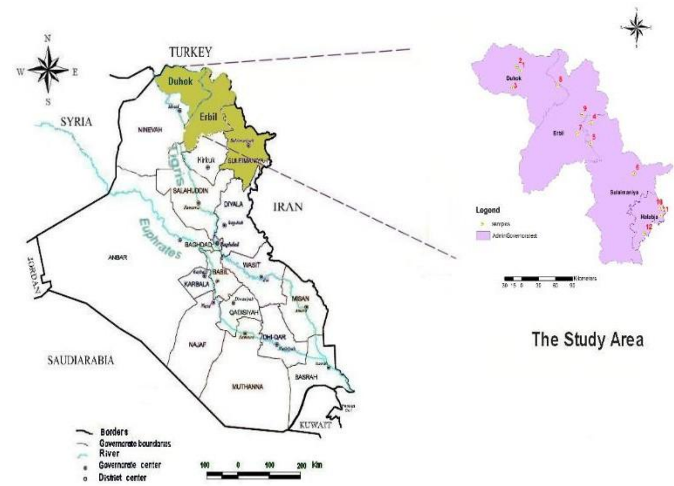

Fig. 1. Location map showing the investigated positions.

After that the clay samples were divided to two parts, the first part was saturated with magnesium by $MgCl_2$ (0.01 N) and the second part was saturated with potassium by (KCl) (0.01 N), and five slides were prepared for each sample two of them from magnesium saturated part which was (Mg saturated air dry and magnesium saturated treated with ethylene glycol, and three slides from Potassium saturated part which was (potassium air dry, potassium heated upon 350ºC, and potassium heated upon 550ºC.

III. Results & Disussion

The common unit for the measurement of the distance between planes, known as lattice spacing or inter micellar spacing, is the angstrom (1Å = 0.1 nm), which corresponds to the unit of X-ray wavelength.

Pre-treatment of the clay sample, like the saturation of the mineral with K, Mg, or Mg plus glycolation, and heating at 550 °C, effects certain shifts in spacing that are characteristic of the type of mineral.

Peak height was used as a rough indicator of relative abundance of minerals (April, et.al, 2004). In general, the expansion of 14 Å to 17 Å in ethylene glycol treatment was not detected because measuring started from 5θ (degree 5 theta), so chlorite cannot be differentiated from smectite under this treatment.

Real chlorite was characterized by 14 Å reflection, which remains the same under all treatments, while swelling chlorite was characterized by 14 Å reflection, and remains the same in Mg-saturation air dry, ethylene glycol saturation, K-saturation air dry, K-saturation upon heating to 350ºC, while it disappears in K-saturation upon heating to 550ºC. The difference between the two types of chlorite (Real and Swelling) is depending on the resistance of a mineral to the destroy in heating treatment, i.e. the real chlorite is high resistance for the temperature and this depending on well crystalline structure, for distinguishing between real chlorite and swelling chlorite at 550°C third-order of chloride d-spacing was used which was equal to (4.2 – 4.7).

The identification of dominant clay minerals depended on the peak height as shown from Fig. 2 to Fig. 5. In general, the swelling chlorite being the dominant mineral in the forest soils.

The occurring of swelling chlorite in investigated soils is due to the deposition of hydroxyl materials (Fe-Hydroxides or Mg-hydroxides) within the interlayer spaces of expansible layer silicate such as smectite because an increase of such elements in the surface horizon of soils could be due to positive differences between element input fluxes, principally by mass flow, minerals weathering, and organic matter mineralization and element output fluxes [15].

Dixon [16] were observed that more frequently hydroxyl inter layering is greatest in the surface horizon and decrease with depth, this depends on the amount and types of complexes between organic acids such as fulvic and humic with cations in soil solution as we know that the studied soils were calcareous and the Ca^{+2} and Mg^{+2} are dominant in soil solution and these cations are ready to make a complexes with these organic acids, and all divalent cations complexes with humic acids are non-soluble, this is the first stage of hydroxyl interlayer formation inside the interlayers of 2:1 expandable minerals.

Numerous studies have been done on these complexes in the Kurdistan region well support this hypothesis, such as [3, 9]. These complexes are non-soluble and non-leachable, so they were dominant in the surface horizon and decreased with depth these findings are in agreement with Dixon [16].

In general, both types of mica (biotite and muscovite) and even illite minerals are identified from the first order at two groups of d-spacing, the first one started from 9.9 Å till 10.5 Å which represents the low weathered mica, the 10.5 Å exactly d-spacing represent palygorskite mineral. The second group of identify mica groups start from 10.5 Å – 11 Å which represents the high weathered mica while the 11 Å is the point of starting interstratified mineral identification.

The distinguish between two types of mica which were muscovite and biotite depending on the second-order of mica (5 Å), in muscovite the peak of the second-order is always strong and high while it's disappeared or very weak in biotite. Also, the six orders of mica were used for distinguishing between mica biotite and muscovite, if the six order of mica was equal to 10.5 Å, it means that the present mica was muscovite, but if the six order was equal to 10.54 it means that the present mica was biotite The disappearing of 10 Å in the first three treatments (Mg air dry, Mg plus ethylene glycol, and K air dry) at Bilah and Badawan sites, with appearing of 14 Å in these above treatments and then follow by appearing of 10 Å in 550 °C treatment leads to thinking about high weathering in these location, i.e. the high weathering of mica mineral which caused by high precipitation (1256 mm/ year) in these locations lead mica weathering toward 14 Å intensively so that's why we didn't find 10 Å in first three treatments at the same time the 10 Å peak founded in 550 °C treatment, which explain that the source of 14 Å in these soils is mica and the heating treatment 550 °C caused to collapsing the lattices and shift toward 10 Å. The appearance of 12 Å at potassium air dried treatment which belongs to interstratified minerals was supports this explanation. Kaolinite is characterized by 7 Å reflection and remains the same in Mg-saturation air dry, ethylene glycol-saturation, K-saturation air dry, and K-saturation 350ºC, while it disappears in K-saturation 550ºC.

Swelling chlorite was appeared in all studied soils (forest and non-cultivated), while real chlorite disappeared in all locations, since 14 Å d-spacing disappeared in treatment of 550°C, while to make us sure that swelling chlorite was rather than vermiculite in studied soils depending on the third order of chloride which was (4.2 – 4.7) Å which appear in the 550 ºC, which indicated that swelling chlorite represents in all studied soil samples. Swelling chlorite was recorded at 11 locations of forest and uncultivated soils as shown in Tables II and III, it means that 92% of the forest and un-cultivated soil samples recorded the highest swelling chlorite content except for Brifca forest site and Malakan un-cultivated site the dominant clay mineral at these sites was muscovite which represent 8% of the studied soil samples.

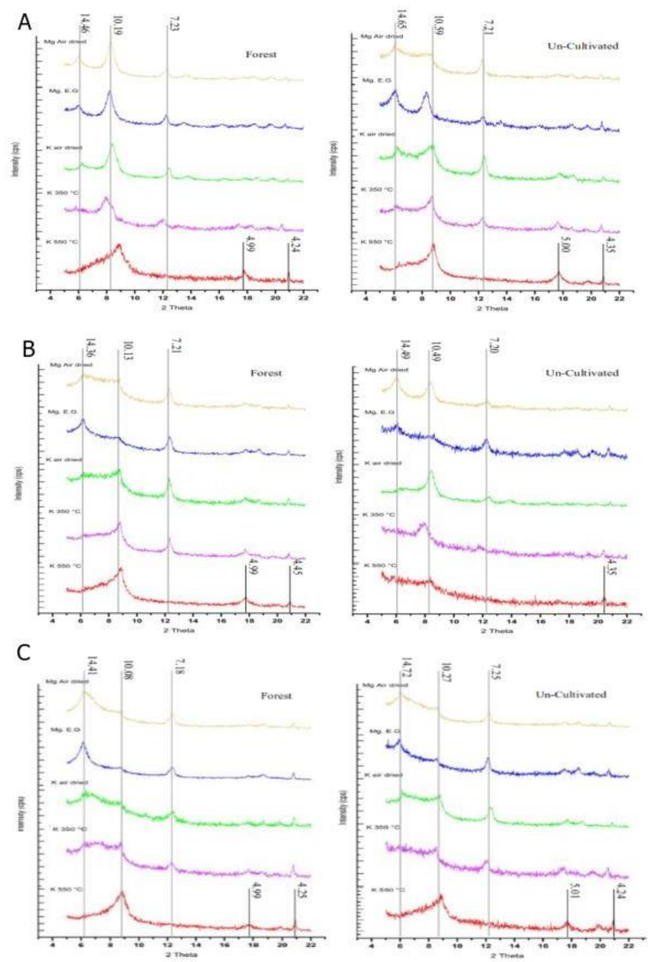

Fig. 2. X-ray diffraction pattern for clay fraction in (A: Brifca, B: Gara, C: Matin) sites at Duhok Province.

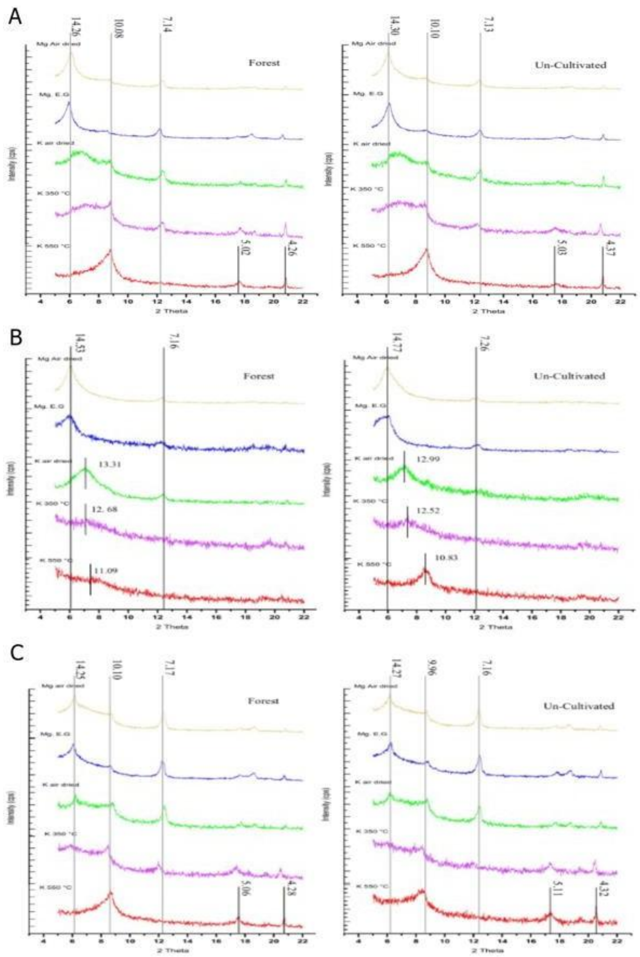

Fig. 3. X-ray diffraction pattern for clay fraction in (A: Awagrd, B: Bilah, C: Malakan) sites in Erbil Province.

TABLE II. THE ABUNDANCE OF CLAY MINERALS IN FOREST SOIL SAMPLES

Site	S. Chlorite	R. Chlorite	Mica	Kaolinite	Non-clay minerals
Brifca	+++	——	++++ Muscovite	++	Quartz K-Feldspar
Gara	++++	——	+++ Muscovite	++	Quartz K-Feldspar
Matin	++++	——	+++ Biotite	++	Quartz K-Feldspar
Awagrd	++++	——	+++ Biotite	++	Quartz, Dolomite K-Feldspar
Bilah	++++	——	——	++	Quartz
Malakan	++++	——	+++ Muscovite	++	Quartz K-Feldspar
Badawan	++++	——	——	++	Quartz, Dolomite K-Feldspar
Bardanga	++++	——	+++ Muscovite	++	Quartz, Dolomite K-Feldspar
Chwarta	++++	——	+++ Muscovite	++	Quartz, K-Feldspar
Bakhakon	++++	——	+++ Muscovite	++	Quartz, Dolomite K-Feldspar
Hawar	++++	——	+++ Biotite	++	Quartz K-Feldspar
Sartak	++++	——	+++ Biotite	++	Quartz, Dolomite K-Feldspar

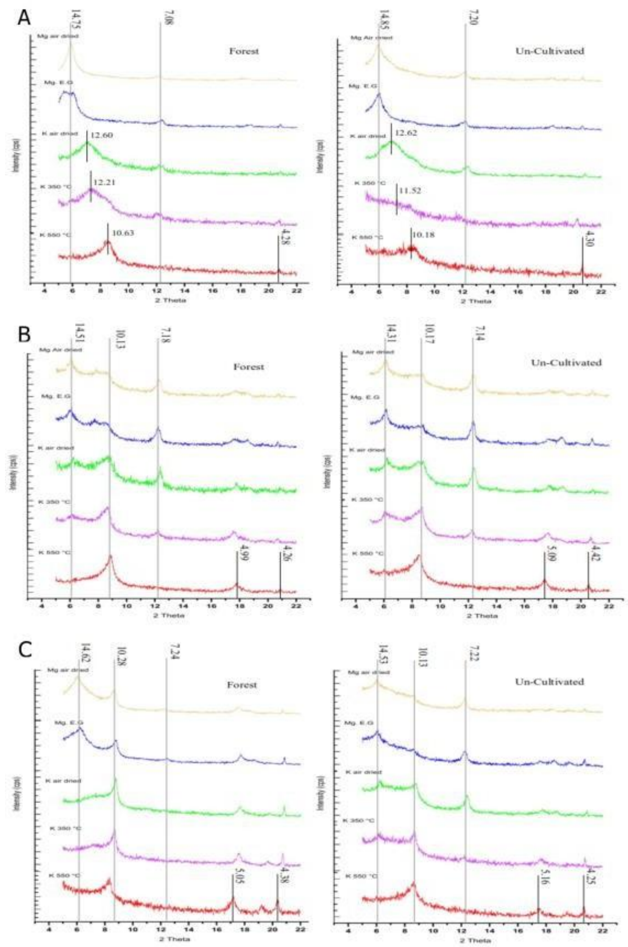

Fig. 4. X-ray diffraction pattern for clay fraction in (A: Badawan, B: Bardanga, C: Chwarta) sites in Sulaimani Province.

TABLE III. The abundance of clay minerals in un-cultivated soil SAMPLES

Site	S. Chlorite	R. Chlorite	Mica	Kaolinite	Non-clay minerals
Brifca	++++	——	+++ Muscovite	++	Quartz K-Feldspar
Gara	++++	——	+++ Biotite	++	Quartz K-Feldspar
Matin	++++	——	+++ Muscovite	++	Quartz K-Feldspar
Awagrd	++++	——	+++ Biotite	++	Quartz, Dolomite K-Feldspar
Bilah	++++	——	——	++	Quartz, Dolomite K-Feldspar
Malakan	+++	——	++++ Muscovite	++	Quartz K-Feldspar

Badawan	++++	——	——	++	Quartz, Dolomite K-Feldspar
Bardanga	++++	——	+++ Muscovite	++	Quartz K-Feldspar
Chwarta	++++	——	+++ Biotite	++	Quartz K-Feldspar
Bakhakon	++++	——	+++ Biotite	++	Quartz, Dolomite K-Feldspar
Hawar	++++	——	+++ Muscovite	++	Quartz K-Feldspar
Sartak	++++	——	+++ Biotite	++	Quartz K-Feldspar

++++ Dominant 50 – 90%
+++ Major 20 – 50 %
++ Minor 5 – 20 %
+ Trace < 5%
Non-clay minerals detected

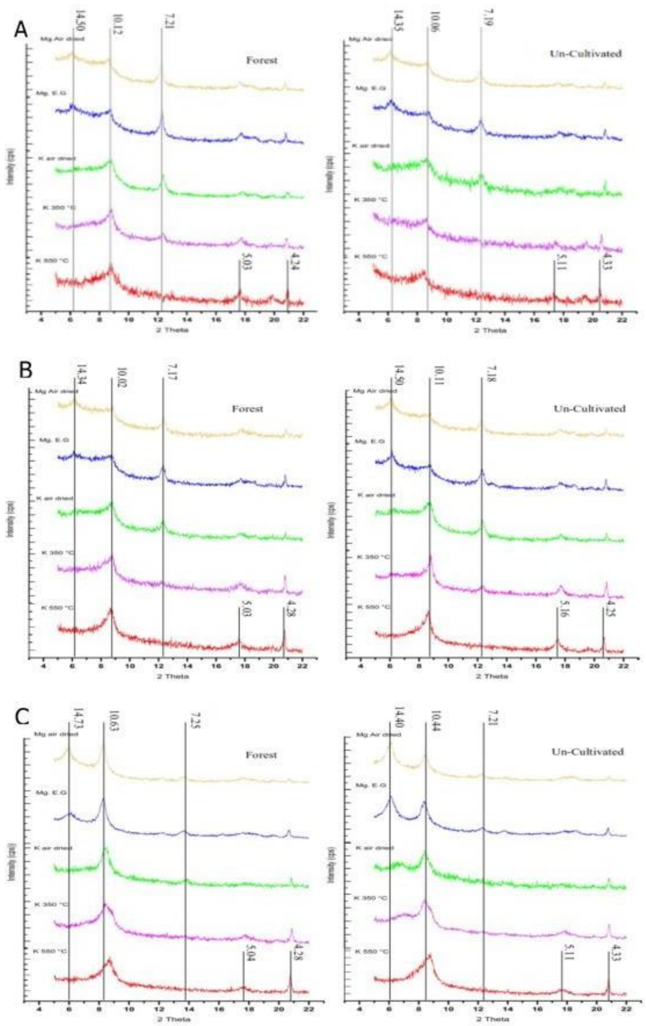

Fig. 1. X-ray diffraction pattern for clay fraction in (A: Bakhakon, B: Hawar, C: Sartak) sites in Halabja Province.

The dominant type of mica at forest sites was muscovite which was obtained from 6 sites, while biotite obtained from 4 sites. But in un-cultivated sites both types of mica (biotite and muscovite) recorded at 5 sites as shown in Tables II and III.

It appears that muscovite was recorded from 50% of forest sites and 41.67% of un-cultivated soils, while biotite recorded at 33.3% of forest sites and 41.67% of un-cultivated soils; both mica mineral types were not recorded from 16.67% of studied soils or not recorded at Bilah and Badawan sites. The kaolinite clay mineral has existed in miner amount (5 – 20) % of all forest and un-cultivated soils. Tables II and III also shown that non-clay minerals such as (Quartz and K-Feldspar) were recorded from all studied forest and uncultivated soils, except Bilah forest site, the only non-clay minerals which observed at this site was quartz, while the Dolomite was recorded from five forest soils and four un-cultivated soils which were equal to 41.67 % and 33.33% of the studied forest and un-cultivated soils respectively.

IV. Conclusion

Based on the obtained results from the current study, the order for dominant clay minerals of studied soils was as follows: (Swelling chlorite > mica muscovite) which were recorded at (92% and 8%) of the studied soils respectively. The dominant mica mineral in forest soils was mica muscovite which was more weatherable.

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