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IDENTIFICATION AND DISTRIBUTION OF MINERALS IN SOILS FROM AL-AHRAR AREA, WAIST PROVINCE, IRAQ

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Abstract: The clay mineralogy of soils and of the main calcareous sedimentary soils of middle of Iraq were investigated to determine the presence of different clay minerals and their distribution pattern in soils. Six pedons were chosen and total of 24 soil horizons were collected. The results revealed that the soil minerals were primary and others were secondary minerals. Generally, the results of the semi-quantitative distribution of the clay minerals in clay fractions showed the dominance of the montmorillonite minerals and illite alternate with chlorite in being main and kaolinite are major, while, the presence of palygorskite mineral were trace except P5 may be miner (saline soils). The origin of the montmorillonite minerals in these soil may be inherited in origin from the mica. Soil chlorite was found in some soils due to chloritization of expanding clay minerals. The mineralogical distribution in bulk soils were dominated by calcite, and quartz, while other minerals were identified feldspar, hematite and pyroxene in addition to the clay minerals in all the soil samples.

Keywords: Clay Minerals, Montmorillonite, Muscovite, Chlorite, Kaolinsite, Palygorskite.

1. Introduction

With an equivalent spherical diameter of < 2 μm, clay particles are produced through various geochemical processes such as weathering and metamorphism [1]. Clay exists in the Earth's crust, ocean and sediments. Clay is one of the fundamental constituents of soil; it influences many soil properties, physical and chemical attributes, soil biogeochemical functions, and the services it pro-vides [2]. Because of their size and microstructure and their unique properties and important in many natural processes, clay-size fine particle fraction (clay-size minerals) account for major portions of soil biochemical studies. However, clay (< 2 μm sized particles) encompasses a variety of minerals that differ widely in physical structure and chemical composition and reactivity, and are distributed heterogeneously in soil, both horizontally and vertically.

Therefore, utility may be found not only in the distribution of total clay content in soil but also in the mineral composition of the clay to account for patterns in soil function or behavior. The large and effective ability of soils to hold water, as well as the ability to swell and shrink due to the presence of expanding minerals as a group smectite [3]. Because of the technical difficulty in quantifying clay-size minerals [4], most identifications were originally obtained by X-ray diffraction (XRD) analysis [5], [6]. The range of clay-size minerals that occur in soils were smectite, kaolinite, illite/mica, vermiculite, chlorite, calcite, iron (Fe) oxide, quartz, feldspar, non-crystalline (amorphous and short-range-order minerals), and others.

Therefore, the study of clay minerals enjoys the attention of specialists in the field of all soils as a whole successfully developing programs and plans for management. Soil mineral studies give a clear picture about the evolution of these soils, conditions and ages which are arranged, as well as reflect the chemical and physical interactions in them D. Knowing the state of fertile soil, and predicting its productivity [7]. The study of the mineral composition of soil is one of the important ways to characterize the intensity of soil formation factors with high accuracy in terms of variation in the geological composition or sedimentation conditions of the source material as well as the extent of homogeneity in the soil body and the degree of weathering that has been exposed. Therefore, the study of the mineral composition was used as an important indicator in distinguishing the intensity of soil formation factors in the original materials. For the processes of weathering and soil formation and their evolution [8]. The aim of the investigation is to identify, distribution and content of different minerals in soils from Al Ahrar area, waist Governorate.

2. Materials and Methods

Study Site The study sites are located in north of Waist province, middle east of Iraq (Figure 1). The region is situated in arid and region, with an average annual precipitation of less than 200 mm and an annual average temperature of 25 $^{\circ}$ C. Depending on the previous morphological and classification studies carried out in some soils from Al-Ahrar area, Waist Governorate [9] six locations have been chosen and 24 soil samples were collected from different horizons. Soil samples were air-dried, then ground and sifted with a sieve with a diameter of 2 mm. The soil samples were saved in nylon bags and containers for further physical and chemical analyzes. The < 2 μm clay fraction and whole soils of 24 soil samples were used in this study. All chemical pretreatments (interlayer cation exchange, acetate buffer reaction) were performed following Jackson's (1979) procedures. Oriented preparations were produced by pipetting a clay slurry onto a glass slide. Clays were solvated with ethylene glycol by pressing the dry preparation upside down against absorbent paper wetted with ethylene glycol and allowing the composite to remain overnight in this position. Excess ethylene glycol was removed just before recording the XRD pattern by pressing the preparation against dry absorbent paper. Mineralogical analysis for clay fraction and whole soils were carried out by XRD instrument. The X-Ray diffraction measurements were recorded from 2° to 75° using a scanting Pad V Diffract-meter with Cu Kα radiation. The instrument utilized 2 mm divergence slit, 4 mm incident scatter slit, 1 mm diffracted beam scatter slit, 0.5 mm receiving slit, an accelerating voltage of 40 kV and a current of 30 mA. Scan parameters used were step sizes of 0.02° and a dwelling time of 2 sec. The semi-quantitative determination of the clay minerals was based on the differences of reflection patterns from K-saturated, Mg-saturated, glycerol, heated, and air-dried samples. The unweathered rocks were also examined by x-ray diffraction and patterns were recorded over a range of 2 -60 degree 2θ [5].

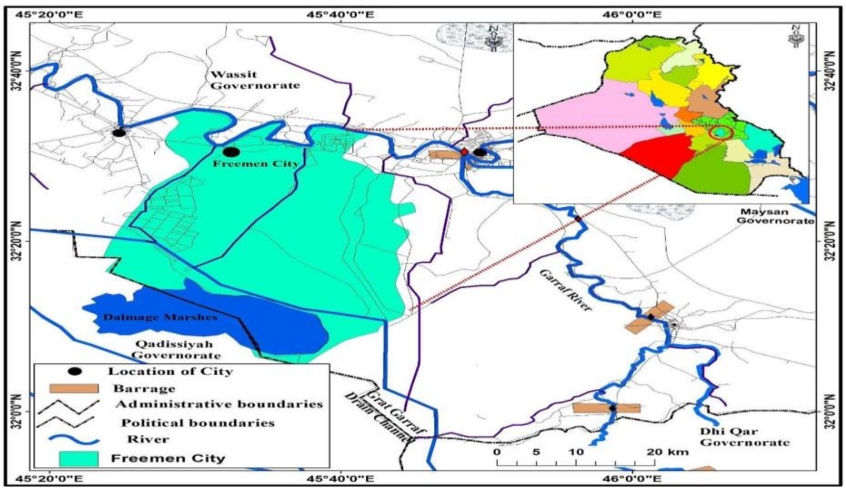

Figure 1. A map representing the study area.

3. Results and Discussion

The mineral compositions of the soil samples were determined by X-ray diffraction (XRD), and the results clearly indicated that different percentages of minerals were identified. Some of these minerals were primary and others were secondary minerals. The results of the XRD curves were shown in Figure (2,3,4,5) for the clay fractions and the minerals can be differentiated on the bases of basal spaces for different treatments. The presence of the basal distance (1.418 nm) with Mg2+ saturation and the peak extended to (1.656 nm) in the treatment with Mg2+ and ethylene glycol, and the disappearance of the diffraction peak in the air-dried K+ treatment, and heated to 550 ° C. This indicated the presence of Montmorillonite. The results also showed the presence of Kaolinite through its appearance at the base distance (0.709 nm) in K+ saturation treatments, air dried, Mg2+ saturation treatment, air dried, and ethylene glycol treatment. The heating at 550° C of K + saturation samples led to the disappearance of the 0.709 nm peak, so, it can be concluded the presence of kaolinite clay mineral in all the soil samples. While XRD peak at 1.4169 nm was observed and stabled in all treatments indicating the presence of chlorite minerals in clay fraction. It is noticed that in K+ saturation the intensity of 1.41nm sharp peak increased. Iolite clay mineral was identified by presentence of 0.939 nm basal spacing, which remained constant in all treatments. The presence of palygorskite mineral in the clay fraction can be identified through its appearance at the 1.051-1.06 nm basal spacing with a constant value in all treatments, except for the treatment of K+ saturation and heated at 550 ° C, which led to the disappearance of this base distance.

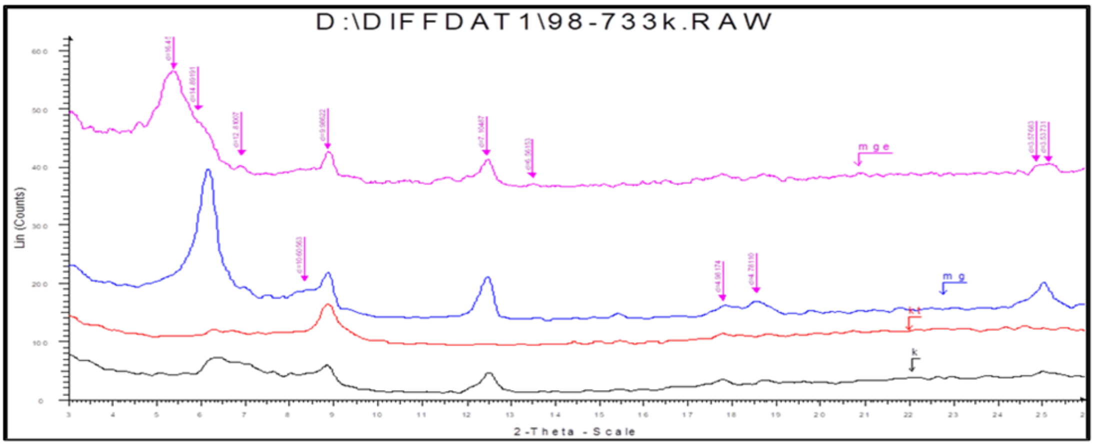

Figure 2. X-Ray diffraction for Clay fraction of the Ap horizon of pedon 2.

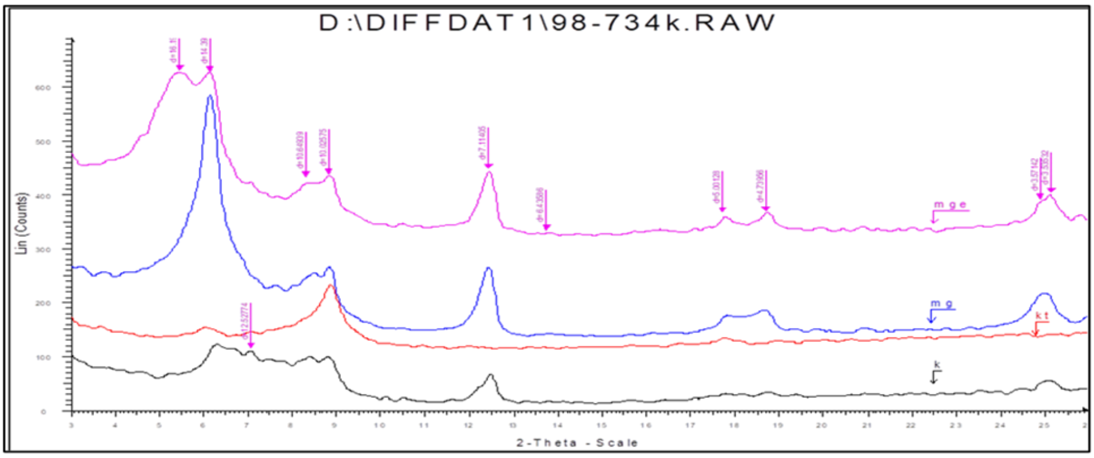

Figure 3. X-Ray diffraction for Clay fraction of the Ck1 horizon of pedon 2.

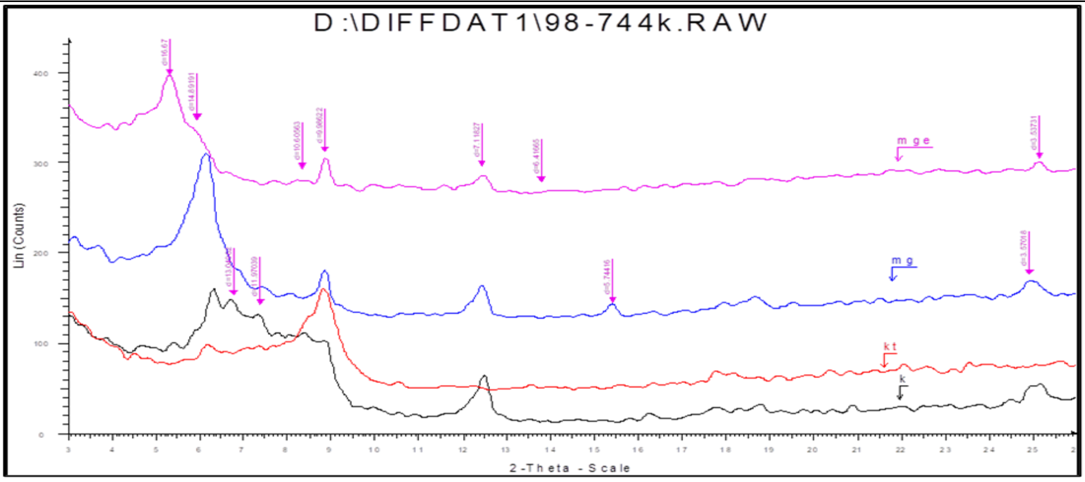

Figure 4. X-Ray diffraction for Clay fraction of the Ck2 horizon of pedon 4.

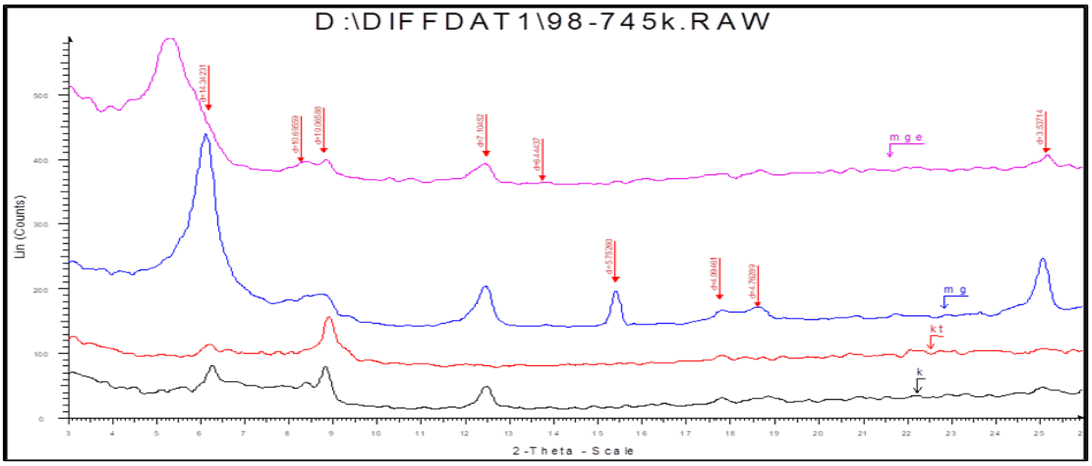

Figure 5. X-Ray diffraction for Clay fraction of the Ck3 horizon of pedon 4.

It was also possible to diagnose amphibole minerals through XRD at the peak 0.850 nm with a constant value without change during all treatments, while olivine minerals were identified by the presence of peaks 0.461, 0.3003 and 0.291nm with constant values in all the different parameters. Calcite was observed in all the clay samples and can be identified by the presence of 0.304, 0.386 and 0.210 nm basal spacing and dolomite was distinguished in some clay samples by its appearance at the peaks of 0.2883 and 0.2191 nm. The presence of the 0.334, and 0.18nm with sharp reflection indicated the presence of quartz mineral with a high degree of crystallization. The hematite mineral was identified in the XRD by the presence of 0.271, 0.2696 and 0.184 nm peaks, while the feldspar mineral identified through its presence at the peaks 0.37, 0.31, and 0.4 nm. The d-spacing of the mica mineral diffraction indicates a low level 1.0 nm peak with a sharp diffraction peak and the presence of the second diffraction of mica minerals at the base distance d-spacing 0.50 nm, as the diffraction within the treatment of Mg2+ saturation and the air drying appeared clearly and with high intensity in all clays of the study soil which confirmed the predominance of the muscovite mineral [10] whom they showed that the type of cations occupying the octahedral layer has an effect on the intensity of diffraction of 0.50 nm. In the case of muscovite, aluminum occupies the octahedral sites, the diffraction (0.50 nm) is strong, while the presence of the iron ion occupies those sites due to a weakness in the intensity or absence of diffraction is 0.50 nm as for the biotite mineral. These results were in agreement with the results obtained by many studies conducted on the sediments of the Tigris River. [11], [12] showed that the Tigris deposits were high in their content of the muscovite mineral within the Iraqi alluvial plain.

The results of X-ray diffraction of the study soil clays showed high diffraction intensity 1.4 nm peak at the expense of diffraction intensity of 1.0 nm peak within the potassium saturation treatment, and the presence of

0.702 nm diffraction of air dried Mg2+ saturation and ethylene glycol treatment, which leaded to an increase in the intensity of diffraction. Whereas, the failure to completely collapse the diffraction 1.38 nm peak to the peak of 1.0 nm montmorillonite when treated heating to a temperature of 350 ° C enhances the presence of the earth chlorite metal due to the resistance shown by the inner hydroxide layer and the collapse of the summit upon heating 550° C [13] and these results are consistent with what had been found by [11]. This condition may be explained by the presence of the soil chlorite in the clays fractions of those soils. This was confirmed [14], [15] that the phenomenon of chloritization is common in soils.

The ground water was rich in base cations that presented between the inner layers of the clay mineral during the hydration caused, and their crystallization in the form of hydroxides when the drought resulting from the decrease in the ground water level during the successive seasons of the year. Thus, the accumulation of salts is one of the appropriate conditions for the process of deposition of the brucite layer within the inner layers of the mineral montmorillonite and its transformation towards chlorite.

The results of the mineral composition of the clays of the study soils for the different horizons of all the pedons indicated a convergence in the proportions of different minerals. The presences of main clay minerals were montmorillonite, chlorite, mica and kaolinite minerals, in addition to palykorskite minerals. The results also did not show an interstratification in the study soil clays fractions, which may be a result of the case of the transformation of mica minerals towards the expanded clay of minerals 1.4 nm, which reflects the weak weathering processes. The presence of Kaolinite is either inherited from the parent material that had been transported by the Tigris river during the flooded time, from Turkey and north of Iraq. Generally, the results of the semi-quantitative distribution of the clay minerals in clay fractions showed the dominance of the montmorillonite minerals and illite, chlorite and kaolinite are major (Table 1), while, the presence of palygorskite mineral were trace except P5 may be miner (saline soils). However, there are many studies of the mineral composition of sedimentary soils located along the Tigris River in different regions within central and southern regions of Iraq, which confirmed the predominance of the smectite mineral, followed by the minerals of mica and chlorite kaolinite in addition of palygorskite. These results were in agreement with the results obtained by [12]. They indicated that the predominance of smectite minerals in these soils may be due to the high percentage of magnesium in the soils and high level of ground water [9].

The reason for the predominance of montmorillonite minerals in the soil horizons of the studied soils may be due to the presence of appropriate conditions for its formation, such as soil pH that tends to be alkaline and the increased the dissolved and exchanged calcium ions [16]. He explained that the low amount of rain falls and increased in the activity of evaporation process the hexagonal oxides and the bases will enter the reactions between them to form smectite mineral and those conditions prevail in the study areas. The studied area is in a dry region of Iraq with a less than 100 mm rain falls per a year. There were studies on the mineral composition of clay fractions in dry and semi-arid conditions and confirmed that the presence of calcium carbonate in the soil is responsible for the predominance of montmorillonite mineral under alkaline conditions where there is an increase in the amounts of Ca, Mg, Fe, and high amounts of Si / Al compared to a small percentage of the H concentration [10] while illite is formed in the presence of K in soil.

From the results obtained, it can be concluded that smectite is the predominant mineral, and that chlorite alternates with mica in being main, and that the origin of the mineral smectite in these soil may be inherited in origin from the mineral mica. There are studies on the origin of the mineral smectite, especially in developed soils in northern Iraq, where it was found that the process of alteration of mica minerals towards smectite was high in the soils under forest trees in comparisons with control soil that little alteration of mica [1]. These results are consistent with those found by [17], [18].

Table 1. Results and semi – quantitative distribution of clay separators.

Pedons	Horizons	Smectite	chlorite	Illite	kaolinite	Palygorskite
P1	Ap	+++	+++	++	++	+
	Ck1	+++	++	++	+++	+
	Ck2	++++	+++	+	++	+
	Ck3	+++	++	+	++	+
P2	Ap	+++	+++	++	++	+
	Ck1	++++	+++	++	++	+
	Ck2	++	++	+	++	+
	Ck3	+++	+++	++	+	+
P3	Ap	+++	+++	++	+	++
	Ck1	++++	++	++	++	+
	Ck2	+++	++	+	++	+
	Ck3	+++	++	+	+	+
P4	Ap	++++	++	+	++ +	+
	Ck1	++++	++	+	++	++
	Ck2	+++	+++	++	+	++
	Ck3	+++	++	++	++	+
P5	Ap	+++	++	++	+++	+
	Ck1	+++	+++	++	++	+
	Ck2	++	++	++	+	++
	Ck3	+++	++	+	++	+
P6	Ap	++	++	++	++	++
	Ck1	++	+++	+	+++	+
	Ck2	++++	++	+	+	+
	Ck3	+++	++	++	+++	+

4. Conclusion

The semi-quantitative distribution of the clay minerals in the clay fractions revealed that montmorillonite minerals and illite alternate with chlorite in being the main and kaolinite are major, whereas palygorskite minerals were only present in trace amounts, with the possible exception of P5 (saline soils). Due to the chloritization of expanding clay minerals, soil chlorite was discovered in some soils. In addition to the clay minerals, feldspar, hematite, and pyroxene were also found in all of the soil samples. Calcite and quartz dominated the mineralogical distribution in bulk soils.

Supplementary Materials:

No Supplementary Materials.

Author Contributions:

F. H. Esaa; methodology, writing—original draft preparation, F. H. Esaa, and J. K. Kassim; writing—review and editing, J. K. Kassim; paraphrasing. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest:

The authors declare no conflict of interest.

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4. References

[1] F. Bergaya and G. Lagaly, "Chapter 1 General Introduction: Clays, Clay Minerals, and Clay Science," *Developments in Clay Science*, vol. 1, no. C. 2006. doi: 10.1016/S1572-4352(05)01001-9.

[2] M. J. Wilson, "The origin and formation of clay minerals in soils: past, present and future perspectives," *Clay Miner*, vol. 34, no. 1, 1999, doi: 10.1180/000985599545957.

[3] A. C. D. Newman, "The significance of clays in agriculture and soils.," *Philos Trans R Soc Lond*, no. A311, 1984, doi: 10.1098/rsta.1984.0035.

[4] J. Środoń, "Identification and Quantitative Analysis of Clay Minerals," in *Developments in Clay Science*, 2013. doi: 10.1016/B978-0-08-098259-5.00004-4.

[5] D. M. Moore and R. C. jr Reynolds, *X-Ray Diffraction and the Identification and Analysis of Clay Minerals, second edition*. 1997.

[6] M. Kahle, M. Kleber, and R. Jahn, "Review of XRD-based quantitative analyses of clay minerals in soils: The suitability of mineral intensity factors," *Geoderma*, vol. 109, no. 3–4, 2002, doi: 10.1016/S0016-7061(02)00175-1.

[7] J. R. Al-Obaidi *et al.*, "The environmental, economic, and social development impact of desertification in Iraq: a review on desertification control measures and mitigation strategies," *Environmental Monitoring and Assessment*, vol. 194, no. 6. 2022. doi: 10.1007/s10661-022-10102-y.

[8] L. A. Douglas, "Clay Mineralogy of a Sassafras Soil in New Jersey," *Soil Science Society of America Journal*, vol. 29, no. 2, 1965, doi: 10.2136/sssaj1965.03615995002900020016x.

[9] S. A. Kadhum, "A preliminary study of heavy metals pollution in the sandy dust storms and its human risk assessment from middle and south of Iraq," *Environmental Science and Pollution Research*, vol. 27, no. 8, 2020, doi: 10.1007/s11356-019-07380-4.

[10] S. N. S. Al Baghdady and L. A. Sagban Alabadi, "Studying and diagnosing the heavy and light sand Minerals for some of the soils in southern and northern Iraq," in *IOP Conference Series: Earth and Environmental Science*, 2021. doi: 10.1088/1755-1315/735/1/012081.

[11] M. Zhang, S. M. de Jong, C. J. Spiers, A. Busch, and H. M. Wentinck, “Swelling stress development in confined smectite clays through exposure to CO2,” *International Journal of Greenhouse Gas Control*, vol. 74, 2018, doi: 10.1016/j.ijggc.2018.04.014.

[12] H. Allafta and C. Opp, “Spatio-temporal variability and pollution sources identification of the surface sediments of Shatt Al-Arab River, Southern Iraq,” *Sci Rep*, vol. 10, no. 1, 2020, doi: 10.1038/s41598-020-63893-w.

[13] A. D. Scott and S. J. Smith, “Sources, Amounts, and Forms of Alkali Elements in Soils,” 1987. doi: 10.1007/978-1-4612-4682-4_3.

[14] J. B. Dixon and M. L. Jackson, “Properties of Intergradient Chlorite-Expansible Layer Silicates of Soils,” *Soil Science Society of America Journal*, vol. 26, no. 4, 1962, doi: 10.2136/sssaj1962.03615995002600040016x.

[15] L. H. P. Jones, A. A. Milne, and P. M. Attiwill, “Dioctahedral Vermiculite and Chlorite in Highly Weathered Red Loams in Victoria, Australia,” *Soil Science Society of America Journal*, vol. 28, no. 1, 1964, doi: 10.2136/sssaj1964.03615995002800010045x.

[16] B. Upendra, M. Ciba, A. Aiswarya, V. V. Dev, G. Sreenivasulu, and K. A. Krishnan, “Mechanisms controlling the dissolved load, chemical weathering and CO2 consumption rates of Cauvery River, South India: role of secondary soil minerals,” *Environ Earth Sci*, vol. 81, no. 3, 2022, doi: 10.1007/s12665-022-10222-1.

[17] A. A. Attiya and B. G. Jones, “Assessment of mineralogical and chemical properties of airborne dust in Iraq,” *SN Appl Sci*, vol. 2, no. 9, 2020, doi: 10.1007/s42452-020-03326-5.

[18] A. Abdullah, A. Esmail, and O. Ali, “Comparison between Mineralogical Properties of Oak Forest and Un-Cultivated Soils in Iraqi Kurdistan Region,” *Journal of Geoinformatics & Environmental Research*, vol. 1, no. 01, 2020, doi: 10.38094/jgier114.