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Influence of climatic variation on soil physiochemical properties and agricultural suitability in northeast of Sulaymani, Iraq.

Salahaddin Abdulqadir Aziz
Department of Natural Resources, College of Agriculture Engineering Sciences, Sulaimani University, Sulaimaniyah, IRAQ
*Corresponding Author: **salahaddin.aziz@univsul.edu.iq**

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ABSTRACT
This study investigates soil properties and agricultural suitability across five sites in northeast Sulaimani Governorate, Iraq: Sulaimani, Sharbazher, Sharazoor, Halabja, and Qaradagh. The sites exhibit a climatic gradient, with annual rainfall ranging from over 850 mm in Sharbazher to less than 350 mm in Halabja, affecting soil characteristics. Soil samples for the main physicochemical properties. Additionally, soil consistency limits, aggregate stability, shear strength, and permeability were evaluated to assess soil quality for agriculture. Organic matter content influenced soil mean weight diameter (MWD), with Sulaimani silty clay loam having the highest MWD (0.80 mm) and organic matter (16.5 g kg^{-1}), while Sharazoor's silty clay had a lower MWD (0.51 mm) and organic matter (12.6 g kg^{-1}). Enhanced organic material improves soil structure and aggregate formation by binding clay particles, increasing aggregate stability by up to 45%. Higher clay content and bulk density increased shear strength, particularly in Sharazoor and Sharbazher. Moisture content influenced cohesion, with maximum cohesion at specific clay contents (471.2–523.1 g kg^{-1}) and bulk densities (1.28–1.31 g cm^{-3}). Increased clay and silt content reduced permeability, while a higher sand content enhanced it. Sodium content reduced permeability by causing clay particle dispersion and pore clogging. Climatic differences significantly influence soil properties. Lower rainfall in Halabja led to higher salinity and pH levels, while higher rainfall in Sharbazher resulted in greater organic matter content and lower salinity. These findings underscore the importance of region-specific soil management practices to enhance soil quality and productivity.

Keywords: *Climate, Mean Weight Diameter, Shear Strength, Soil permeability*.

INTRODUCTION

The northeast region of the Sulaimani Governorate in Iraq features a diverse climate that significantly influences soil properties and agricultural suitability, as discussed by [1]. Climate differences play a crucial role in controlling soil properties such as temperature, moisture, and bulk density, which in turn affect crop growth and productivity. Variations in rainfall significantly influence the amount of organic matter in the soil, depending on factors like plant cover and land use practices [2]. Conventional agricultural systems demand significant energy and often degrade the physical properties of soil, leading to their breakdown [3]; [4]. While tillage can increase soil aggregates and accelerate the renewal rate of total aggregations, it also prevents the formation of stable micro aggregates. Conversely, reducing tillage enhances the overall stability of soil clusters [5]. Higher rainfall areas generally have higher clay content and increased soil shear strength due to enhanced cohesion and internal friction, while drier regions have less clay and lower shear strength, making soils more erosion-prone. The stability and composition of soil aggregations can be severely affected by farming practices such as soil tillage and thus affect the growth and productivity of crops [6].

[1] Also, note that soil organic matter, which affects aggregate stability (measured as mean weight diameter, or MWD), is greater in wetter regions, resulting in larger MWD values. At the same time, drier areas have smaller MWD values. Soil permeability and hydraulic conductivity, essential for water infiltration and retention, are impacted by climatic variations. Wetter regions generally exhibit lower permeability due to higher clay and silt content, whereas drier regions with more sand content tend to have higher permeability. Research has shown that soil tillage significantly increases the mean weight diameter. At the same time, mulching influences soil plasticity, as indicated by Atterberg limit tests, which help understand soil behavior under various conditions (Coduto, p. 128). For example, minimum tillage can increase MWD by 8.69%, while conventional tillage can lead to a 73.91% increase [2]. Studies have linked soil aggregate stability to primary soil characteristics like texture, clay mineralogy, organic matter, and calcium carbonate [7]. However, fewer studies have explored the relationship between stability and environmental factors such as landscapes and vegetation types [8]; [9]. Assessing aggregate stability along with climatic, environmental, and soil surface coverage factors is crucial for predicting soil productivity. These parameters are pivotal in determining soil health and management practices. This study aims to

elucidate relationships between soil aggregate stability and surface coverage factors, providing insights for more efficient soil management. Research by [1] found a notable decrease in soil penetration resistance due to mechanical pulverization and repeated wetting and drying cycles, which also increased soil porosity, highlighting the impact of these processes on soil physical properties.

MATERIALS AND METHODS

1. Study Area and Soil Samples:

The study area includes the northeast region of Sulaimani Governorate, Iraq, including five distinct sites: Sulaimani, Sharbazer, Sharazoor, Halabja, and Qaradagh (Figure 1). These sites exhibit a significant climatic gradient and are cultivated with various crops, with varying annual rainfall from south to north, ranging from over 50 mm in Sharbazoor to less than 450 mm in Halabja.

2. Soil Consistency Limits:

The Casagrande liquid limit device was used to determine the liquid limit, and the plastic limit was identified when the soil sample broke at 3.175 mm in diameter. Moisture content at these limits provided quantitative measures. Equations for mass, liquid limit, plastic limit, moisture content, flow index, and plasticity index were applied to determine the Atterberg limits and classify soil types. Increasing soil organic matter is crucial for enhancing soil physical and mechanical properties, particularly in arid and semiarid regions. This laboratory study aimed to assess the effects of organic matter on soil consistency limits, liquid limit (LL), plastic limit (PL), plasticity index (PI), and soil compatibility parameters across soils with various textures. The SOC, consistency limits, and plasticity index (PI = LL + PL) were measured for the soil taken from the 0–30 cm layer. Casagrande used his mechanical liquid limit device with a number of different soils. He found that plots of water content versus the logarithm of the number of blows were straight lines for all soils tested. He called such plots “flow curves” and described them with the following equation: $w = -F \log (N) + C$. Where: w = water content (%), F = constant, called “flow index," N = number of blows, and C = constant.

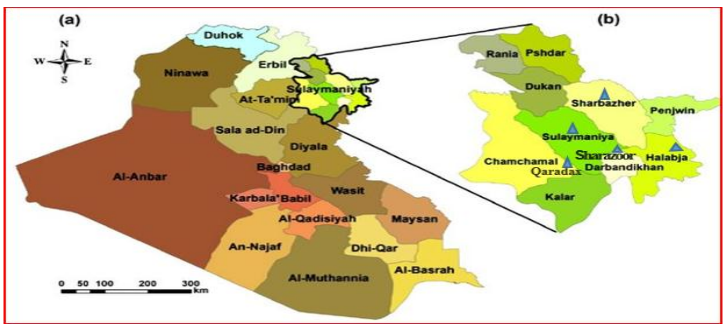

Figure 1. The study area and the distribution of sample points

3. Physical and Chemical Analysis of Soil:

Table 1. Show the chemical and physical analyses involved in determining particle size distribution after organic matter removal using (30% H_2O_2 [10], pH measurement (1:2.5), salinity measurement in a soil-water extract (1:5) with a conductivity meter [11], total calcium carbonate content measurement according to [12], and organic matter quantification through wet oxidation (K2 Cr2 O2) [13].

Table 1. presents the selected physical and chemical properties of the study soil across various locations.

Characteristic	Unit	Sulaimani	Sharbazher	Sharazoor	Halabja	Qaradagh
Sand	g Kg^{-1}	59.68	111.37	96.9	61.4	309.8
Silt	g Kg^{-1}	619.17	417.19	380	428.66	438.5
Clay	g Kg^{-1}	321.15	471.28	523.1	510.1	251.7
Textural class	-------	Silty Clay Loam	Silty Clay	Silty Loam	Silty Clay	Loam
Bulk Density	Mg m^{-3}	1.4	1.44	1.3	1.26	1.52
ECe at 25 C	ds.m^{-1}	0.38	0.48	0.45	0.78	0.63
pH	--------	7.42	7.71	7.95	7.22	7.42
Organic matter	g Kg^{-1}	19.59	19.91	22.5	23.7	16.12
$CaCO_3$	g Kg^{-1}	215.68	112.54	212.5	152.3	232
Calcium Ca^{+2}	mmolecL^{-1}	2.0	2.01	4.2	5.12	4.3
Mg^{+2}	mmolecL^{-1}	0.28	0.15	0.9	1.85	0.97
Sodium	mmolecL^{-1}	0.48	0.12	0.8	1.43	0.52

4. Aggregate Stability:

Soil aggregate distribution and stability were evaluated using wet sieving methods, with the mean weight diameter (MWD) calculated [14]. Wet sieving was conducted with sieves ranging from 6.0 mm to 0.125 mm to assess the distribution of aggregates [15]. The mean weight diameter (MWD) was calculated based on the retained weight on each sieve [16].

$$Mean\ Weight\ Diameter = \sum_{i=1}^{n}(X_i \, . W_i)$$

$$X_i = \frac{Wt.of\ aggregate\ retained\ on\ seive\ No.i}{Total\ oven\ dry\ weight}$$

Xi = diameter of sieve opening (6.3, 1.5, 0.75, 0.375 and 0.125 mm)

5. Shear Strength:

Shear strength of soil indicators such as cohesion and internal frictional angle were determined for soil samples taken from agriculture fields in the Sulaimani region and classified into five levels based on different clay content. Statistical analyses, including the Duncan multiple range test and correlation coefficients, were performed using SAS and SPSS software, respectively. A student's t-test was used for comparing topsoil and subsoil in gullies and badlands.

6. Saturated hydraulic conductivity of Soil:

A Saturated hydraulic conductivity of soil test assesses the soil's water transmission capability by measuring the water flow rate through a sample under controlled conditions. The test employed constant head methods [17], where a steady water level was maintained across the soil sample and the flow rate was measured. Test data analysis allowed the determination of the saturated hydraulic conductivity of soil, offering valuable insights for agricultural applications. The Saturated hydraulic conductivity of soil of the sample can be calculated using the formula $K=QL / (A.\ \Delta h.\Delta t)$, where L is the height of the soil sample column, A is the sample cross section, Δh is the constant pressure difference, Q is the volume of passing water, and ΔT is the time interval

Results and Discussions

1. Climate influences soil physical and chemical properties.

The analysis of soil properties in different climate regions of the Sulaimani Governorate reveals significant variations influenced by rainfall and temperature. Table 2 summarizes the findings:

Sharbazher and Halabja: These regions, which receive the highest rainfall (861.0 mm and 395.8 mm, respectively), predominantly have silty clay soils. This suggests that higher rainfall contributes to the formation of silty clay soil, which has a finer texture. Sharazoor: With the lowest annual rainfall (299.6 mm) and the highest temperature (23.0°C), the soil texture is predominantly Silty Loam. The low rainfall and high temperature may promote the development of denser clay soils. Qaradagh: Exhibits loam soil texture with moderate rainfall (659.5 mm) and moderate temperature (17.5°C). The balance between rainfall and temperature in this region likely supports a balanced soil texture with a mixture of sand, silt, and clay. Sulaimani: Displays a silty clay loam texture with an intermediate level of rainfall (420.4 mm) and a moderate temperature (20.4°C), indicating a blend of fine and coarse particles influenced by moderate climatic conditions. Laboratory and fieldwork results show that soil moisture content varies significantly with temperature, influenced by solar radiation's direct and indirect effects on soil [18].

2. Rainfall and temperature Influence:

Lowest Temperature (Sharbazher, 15.2°C): This region has silty clay soil, indicating that cooler temperatures combined with high rainfall favour the formation of finer-textured soils. Highest Temperature (Sharazoor, 23.0 °C): This region's silty Loam soil suggests that higher temperatures, coupled with low rainfall, lead to a more compact soil structure with a higher clay content. Implications for farming techniques in regions with high rainfall (Sharbazher and Halabja), the silty clay soils in these areas can hold more moisture, making them ideal for crops that need consistent levels of water, although they may require careful handling to avoid waterlogging and erosion. Low rainfall, high temperature region (Sharazoor): Clay soils here, with higher density and lower permeability, may pose challenges for crop root penetration and water infiltration, necessitating practices that improve soil structure and water management.

These soils have good water retention and drainage, making them ideal for farming with minimal soil management needs.

Rainfall and temperature variations have a substantial impact on soil bulk density. High rainfall areas typically exhibit lower bulk density due to increased soil moisture and organic matter content, which enhance soil structure and reduce compaction. Conversely, regions with low rainfall and high temperatures tend to have higher bulk density due to reduced organic matter and increased soil compaction [1].

Table 2. Climate Data for Various Location

Characteristic	Texture	Rainfall (mm)	Temperature
Sulaimani	Silty Clay Loam	420.4	20.4
Sharbazher	Silty Clay	861.0	15.2
Sharazoor	Silty Loam	299.6	23.0
Halabja	Silty Clay	395.8	21.2
Qaradagh	Loam	659.5	17.5

3. Influence of Organic Matter Content on Mean weight diameter (MWD):

Table 3 presents the findings of measurements obtained from five distinct soil types with respect to climate. Additionally, however, it was found that there was a highly significant ($P < 0.01\%$) correlation between the organic matter content and soil aggregate stability, which is in agreement with earlier findings [2]. When compared to the different soil climate treatments, the results demonstrated that the impact of organic matter on MWD values varied significantly. The silty clay loam soil from Sulaymaniyah exhibited the highest MWD values. Conversely, the Sharazur silty clay soil showed lower values for both organic matter and MWD, at 12.6 g kg^{-1} and 0.51 mm, respectively. This discrepancy may be due to the slower decomposition of organic material in colder climates. According to [5] organic matter decomposition can be prolonged. Additionally, the average MWD values have increased for soils in both the Sulaymaniyah and Qaradagh locations. This could be attributed to the significant impact of organic material degradation on enhancing soil structure and encouraging the formation of soil aggregates by acting as binding agents for clay particles. These materials contain active aggregates that contribute to aggregate stability by forming sticky, gelatinous materials through decomposition. [19] who discovered that adding more materials that are organic increased soil aggregate stability by 45% as compared to not utilizing them, further supported this. The amount of organic matter in the soil is greatly affected by climatic factors. Higher rainfall and moderate temperatures promote greater plant growth, leading to increased organic matter content. In regions with low rainfall and high temperatures, the decomposition of organic matter is slower, resulting in lower organic matter levels. This correlation between organic matter content and climate was highlighted in studies by [2].

Significant correlation coefficients were obtained for the interactions between the stability of the aggregates ($CaCO_3$, Ca^{+2}, Mg^{+2}, and Na^{+}). The alteration of these characteristics will have to, in some way, be due to changes in the levels of organic matter. The correlation between Na+ and the equality of the aggregates has not been significant. High rainfall areas tend to have lower sodium content due to leaching, while calcium and magnesium levels are higher due to the dissolution of parent material. In drier regions, sodium tends to accumulate, leading to soil salinity issues, whereas calcium and magnesium levels are lower due to reduced leaching and dissolution [4**].**

Table 3: statistical analysis of the Organic matter, bulk density and (MWD) of the soil at differences locations.

Characteristic	Texture	O.M g kg^{-1}	(MWD) mm	ρb g cm^{-3}
Sulaimani	Silty Clay Loam	16.5 a	0.80 a	1.2 c
Sharbazher	Silty Clay	12.6 c	0.51 c	1.31 a
Sharazoor	Silty Loam	14.1 bc	0.61 b	1.28 b
Halabja	Silty Clay	14.7 bc	0.68 ab	1.27 b
Qaradagh	Loam	15.5 b	0.73 ab	1.22 c

The different letters within the same column indicate that there is a significant difference between the treatments at the level of significance $p>0.05$; values were Mean ± standard error.

2-Soil physical properties

Effect of soil texture on soil MWD

Table 4. It showed that the statistically analyzed results of the influence of organic matter content on MWD could be indirectly affected by the composition of soil particles like sand, silt, and clay. Typically, soils with higher clay content tend to have better aggregate stability due to the binding properties of clay particles. Sand particles, being larger and less cohesive, may contribute less to MWD. Silt particles can have intermediate effects. Therefore, in soils with varying proportions of sand, silt, and clay, the MWD values may be influenced by the interplay of these particles along with organic matter content. The correlation coefficients calculated between aggregate stability and these three components for the soils examined here are very small and in no way approach significance. Although the textural range of the soils used in this study was more restricted than in the previous studies, there are nonetheless substantial variations in the amounts of sand, silt, and clay. A clay percentage ranges from 25 to 52%, silt from 38 to 61%, and sand from 6 to 30%. [17] Work showed that an increase in the clay fraction significantly improved water aggregate stability.The composition of any soil is an important factor that influences many soil properties, such as shear strength, liquid limit (LL), plastic limit (PL), permeability, etc. Table 4 shows the results of this study with a change in these properties that affect (MWD) from the range of 1.81 to 0.9 cm h^{-1} as sequenced. This paper examines the effects of treatments that induce organic matter content on the Atterberg limits of four different soil texture classes. The results of regression analysis for shear strength, liquid limit, plastic limit, and permeability in different soil texture classes (Table 3 and Figures 1,2) indicated that organic matter in clay soil texture classes could justify 14.1 g kg^{-1} of the liquid limit variation. Therefore, this is the most important component of the liquid limit.

The liquid limit, plastic limit, and plasticity index values in the studied samples, according to the Casagrande test method, are shown in Tables 1 and 2. Indicate that the plasticity index ranges between 30.1 and 57.9%. This means that the soil in this study is characterized by medium to high plasticity. This means that the soil at the Sulaimani site is characterized by medium plasticity as well. Comparing the average of physical factors with different types of soil by means of the Duncan multiple range test showed that the percentage of clays and the level of MWD, liquid limit, and activity showed significant changes ($p < 0.05$) in some types of soil, whereas other measured parameters had no significant effect on the form and type**.**

Table 4. Presents the statistical analysis of chemical soil properties across different locations

	Treatments					
Sites	K ($cm.h^{-1}$)	τ (kPa)	LL (%)	PL (%)	PI (%)	MWD (mm).
Sulaimani	1.81 a	6.11 c	71.4 b	41.22 a	30.1 b	0.32 ab
Sharbazher	1.62 ab	8.01 a	92.90 a	39.04 b	53.6 a	0.35 b
Sharazoor	1.12 d	8.33 a	96.05 b	38.15 b	57.90 a	0.41 a
Halabja	0.90 c	7.50 b	91.08 a	37.50 b	53.58 a	0.38 a
Qaradagh	1.4 d	7.75 b	72 80 b	40.3 a	32.3 b	0.30 c

The different letters within the same column indicates that there is a significant difference between the treatments at the level of significance p>0.05, values were Mean ± standard error.

Effects Bulk density and clay content on shear strength

Table 5 presents the statistical analysis results of interactive factors affecting shear strength, specifically when the soil wet bulk density was 1.31 g cm^{-3}. Shear strength was observed to increase with higher clay content and bulk density. The maximum soil shear strength was achieved at a clay content range of 471.28–523.1 g kg−1 and a bulk density range of 1.28–1.31 g cm^{-3}, as seen at the Sharbzher and Sharazoor sites.

Clay particles, due to their small size and flat shape, can pack closely together, creating a dense and cohesive matrix. This matrix resists deformation and provides high shear strength. The strong correlation indicates that small changes in clay content lead to significant changes in shear strength, highlighting the importance of clay in soil stability. Compacted soils have fewer voids and more particle-to-particle contact, which can increase shear strength. However, this relationship is not as strong as with clay content, possibly because bulk density can be influenced by factors other than just the soil's texture, such as organic matter content, soil structure, and moisture levels. This suggests that managing clay content is crucial for improving soil shear strength, more so than adjusting bulk density alone.

When the moisture content was high in site of sharbazher, cohesion increased firstly and then decreased with the increase in clay content and density. The maximum cohesion was reached when clay content was between 471.2 and 523.1 g kg^{-1} and density was between 1.28 and 1.31 g cm^{-3} (table 5). The correlation suggests a greater impact of clay content on soil cohesion than bulk density, as the variation rate of cohesion along the direction of clay content was greater than density. Figure 3c shows that cohesion decreased with the increase in bulk density when the clay content was 471.28 g cm^{-3}. The highest shear strength was estimated when the bulk density was within 1.28~1.31 g cm^{-3} table 5).

Table 5. Shows the statistical analysis results of effect Bulk density, clay on shear strength

	Treatments		
Sits	clay g kg^{-1}	ρb g cm^{-3}	Shear strength (kPa)
Sulaimani	321.15 b	1.2 c	6.11 c
Sharbazher	471.28 a	1.31 a	8.01 a
Sharazoor	523.1 a	1.28 b	8.33 a
Halabja	510.1 a	1.27 b	7.50 b
Qaradagh	**251.7 c**	**1.22 c**	**7.75 b**

The different letters within the same column indicates that there is a significant difference between the treatments at the level of significance p>0.05, values were Mean ± standard error.

4. Effects soil physical and soil chemical on soil permeability

Tables 5 and Figure 2. Show the results of the analysis of that there were significant differences in the effect of changing in soil size distribution on the soil permeability, it shows that they had a significant relationship value of R^2 = 0.36, 0.0215 and 0.693 for clay, silt and sand. Respectively. The regression line ($y=-0.0016x+2.0333$ indicates a negative slope, with a moderate correlation (R^2=0.36). Permeability decreases as clay content increases due to clay's small particle size, which reduces pore spaces and limits water movement. While clay content is notable in influencing permeability, other factors may also contribute to its variability. Primary particles had different effects on the final intensity. So that with the increase in the percentage of clay and silt, the intensity of the final penetration a significant decrease has been found. In contrast, sand particles show positive and meaningful permeability. Particles due to its smaller size, clay reduces the size of pores and as a result, the penetration becomes final. Silt particles, though in terms of size, they are considered intermediate between clay and sand particles. However, in this research, they showed a behavior closer to clay have given. Similarly, [20] they found that clay and silt behave differently from sand. Infiltration of water in the soil and production of runoff in a way that causes permeability decreases, while sand increases permeability follows. [21] Found that Water penetration usually in sodic soils, especially those that have high pH and amounts of silt and clay, it is weak. Sand particles, due to their size larger causes the creation of larger voids and in the result of the increase in the final permeability of the soil are follows the above findings with the results obtained by [21]. and it also agrees with [22]. This researcher points to the positive effect of sand in increasing permeability (2003). The negative relationship between the amount of organic matter and the intensity of penetration got they to attribute this finding to the scattering formation of particles in the presence of small or large amounts of organic matter. Sodium has been stated. Due to the relatively wide range of values Na^{+1} of the studied soils (table 1) such a possibility it is not far from the expectation. Generally, sodium soils have high density and low permeability [23]. Harmful effects of sodium due to dispersion of clay particles, especially in heavy textured soils, reduction in soil porosity, reducing the permeability of the soil due to the closing of the soil pores it is guided by water [24]. It is important because the intensity of penetration by the distribution of the size of the defect and their connection in the control soil profile [25].

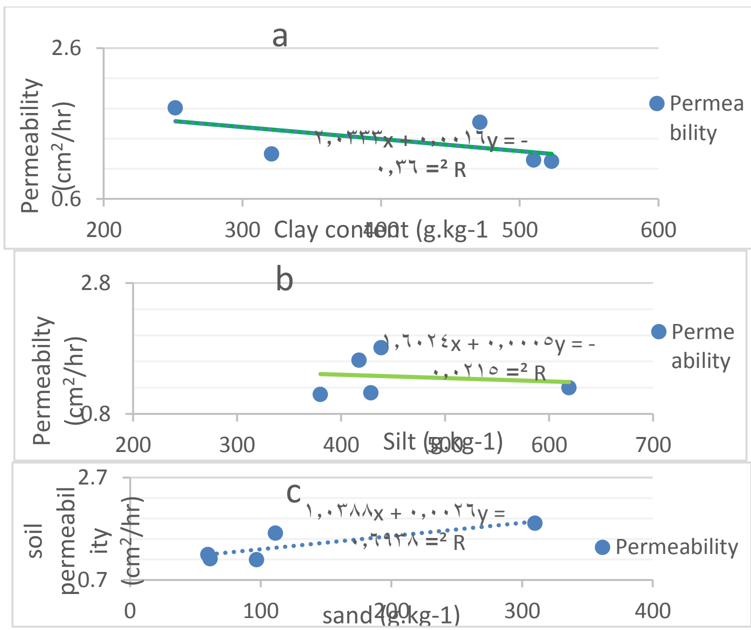

Figure (2) Effect sand, clay and silt (a, b c) on soil permeability

Effect of Variation in Some Physical Soil Properties of Soils Affected by Different Climatic Conditions

The study investigates how various physical soil properties, influenced by different climatic conditions, affect the shear strength of soils across five sites, as shown in Table 5 and Figure 3. The highest shear strength was observed in Sharazoor (8.33 kPa) and Sharbazher (8.01 kPa), while Sulaimani had the lowest shear strength (6.11 kPa). Sharbazher exhibited the highest bulk density (1.31 g cm^{-3}), whereas Sulaimani and Qaradagh had the lowest bulk densities (1.20 g.cm^{-3} and 1.22 g/cm³, respectively). Sharazoor had the highest clay content (523.1 g kg^{-1}), followed closely by Halabja (510.1 g kg^{-1}), and Qaradagh had the lowest clay content (251.7 g kg^{-1}). These results indicate significant variations in physical soil properties and their consequent impact on shear strength across different climatic conditions.

Figure 3. shows that Sulaimani and Qaradagh have the highest sand content due to their coarse soil texture, less influenced by fine particles and organic matter. In contrast, Sharbazher, Sharazoor, and Halabja show similar, lower sand content levels, indicating a finer soil texture with higher proportions of silt and clay. Sulaimani has the highest silt content, possibly due to sediment deposition from water erosion processes. Sharbazher, Sharazoor, and Qaradagh have moderate silt content, reflecting a balance between sand and clay particles. Halabja has the lowest silt content, which may be due to soil composition that favours more sand and clay.

Sharazoor has the highest clay content, likely due to the weathering of fine-grained minerals and limited soil erosion. Halabja and Sharbazher follow with slightly lower clay contents, while Sulaimani and Qaradagh have the lowest clay contents, indicating a more coarse-grained soil composition with less fine material accumulation. The permeability values are relatively low across all locations, with slight variations. Sharbazher and Qaradagh have slightly higher permeability values compared to other places, likely due to their higher sand content and lower clay content, which allows for better water movement through the soil.

These results indicate distinct variations in soil physical properties influenced by climatic conditions across the different sites

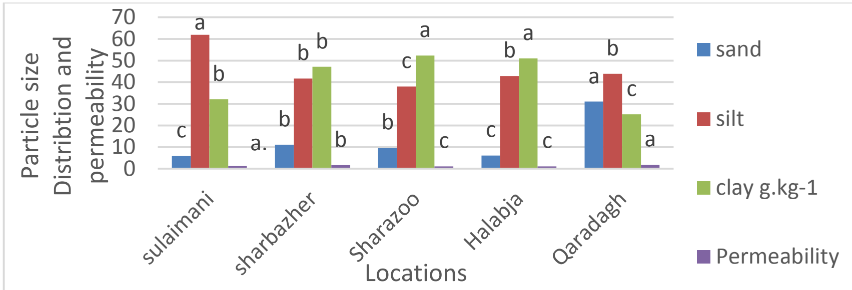

Figure (3) Effect of Variation in some physical soil properties with affected by different climatic conditions

Conclusions

The analysis of soil properties across different climate regions in the Sulaimani Governorate shows significant variations due to rainfall and temperature. High-rainfall regions like Sharbazher and Halabja have silty clay soils, while Sharazoor, with the lowest rainfall and highest temperatures, has a silty loam texture. Qaradagh and Sulaimani show balanced loam and silty clay loam textures, respectively. Cooler, high-rainfall areas favor finer soils, while high temperatures and low rainfall in Sharazoor lead to denser clay soils. Organic matter, which is higher in wetter regions, improves soil stability. Sulaimani's soil has the highest mean weight diameter (MWD), while Sharazoor's soil has lower stability due to slower organic decomposition. There is a significant correlation between clay content, bulk density, and shear strength, with Sharazoor showing higher shear strength. Bulk density is lower in high-rainfall areas due to increased soil moisture and organic matter. Permeability varies slightly, with Sharbazher and Qaradagh having higher values due to more sand content, while higher clay and silt content reduces permeability. These findings highlight the need for tailored agricultural practices: high-rainfall areas require management to prevent waterlogging and erosion, while low-rainfall, high-temperature regions need soil structure improvements and water management

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تأثير التغيرات المناخية على الخواص الفيزيائية والكيميائية للتربة وملاءمتها للزراعة في مدينة السليمانية، العراق.

صلاح الدين عبد القادر عزيز

قسم الموارد الطبيعية، كلية علوم الهندسة الزراعية، جامعة السليمانية، السليمانية، العراق.

الخلاصة

تُقيّم هذه الدراسة خصائص التربة وملاءمتها للزراعة عبر خمسة مواقع في شمال شرق محافظة السليمانية، العراق: السليمانية، شاره زور، شاربازير، حلبجة، وقرداغ. تمتد المواقع على تدرج مناخي، حيث يتراوح معدل هطول الأمطار السنوي من أكثر من 850 ملم في شاربازير إلى أقل من 350 ملم في حلبجة، مما يؤثر على خصائص التربة، تم تحليل عينات التربة لدراسة توزيع حجم الجسيمات، ودرجة الحموضة، والملوحة، ومحتوى كربونات الكالسيوم، والمادة العضوية، وحدود الاتساق، واستقرار الكتل، وقوة القص، والنفاذية. أظهرت النتائج أن المادة العضوية تؤثر بشكل كبير على بنية التربة. سجل معدل القطر الموزون *(MWD)* للتربة الطينية الطينية في السليمانية أعلى قيمة (0.80 ملم) مع محتوى مادة عضوية بلغ 16.5 غم.كغم⁻¹، بينما كان معدل القطر الموزون للتربة الطينية الطينية في شاره زور أقل قيمة (0.51 ملم) مع محتوى مادة عضوية 12.6 غم.كغم⁻¹. أدت زيادة المادة العضوية إلى تحسين استقرار الكتل بنسبة تصل إلى 45٪. تباينت تركيبة التربة بين المواقع، حيث تراوح محتوى الطين من 25% إلى 52%، والطمي من 38% إلى 61%، والرمل من 6% إلى 30%. أشار مؤشر اللدونة (30.1-57.9%) إلى لدونة متوسطة إلى عالية، مما أثر على قوة القص والنفاذية. أدى ارتفاع نسبة الطين والكثافة الظاهرية إلى زيادة قوة القص، خاصة في شاره زور وشاربازير، بينما ساهم ارتفاع محتوى الرمل في تحسين النفاذية. كما أدى وجود الصوديوم إلى تقليل النفاذية من خلال تشتيت جزيئات الطين وانسداد المسام. أثرت الظروف المناخية بشكل ملحوظ على خصائص التربة. ارتبط انخفاض هطول الأمطار في حلبجة بارتفاع الملوحة ودرجة الحموضة، بينما ساهم ارتفاع هطول الأمطار في شاربازير في تعزيز المحتوى العضوي وانخفاض الملوحة. تسلط هذه النتائج الضوء على ضرورة تبني ممارسات إدارة التربة المخصصة لتحسين جودة التربة وزيادة الإنتاجية الزراعية في المناطق المختلفة.

الكلمات المفتاحية: المناخ، معدل القطر الموزون، قوة القص، نفاذية التربة.