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Spatial Modeling Of The Physical Soil Characteristics Of The Area Extending Between Iraqi's Governorates: Muthanna, Al-Diwaniyah And Dhi Qar,Using GIS Technology GIS

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Abstract
This study aims to identify the physical properties of the soils in the region extending between Al-Muthanna, Al-Diwaniyah(Al-Qadisiyah), and Dhi Qar governorates. The examined properties include soil texture, bulk density, particle density, soil porosity, soil moisture content, and soil colour. To achieve this, ten soil samples were randomly collected at a depth of 0–30 cm, with their coordinates determined using GPS. The study also utilized Geographic Information System (GIS) software (ArcGIS 10.7.2) to generate spatial modelling and variability maps for analysis. The results revealed variations in the physical properties of the soil across the study area.
Soil analysis results indicated that sandy loam and loamy sand textures dominate the study area. Bulk density values ranged between 0.94–1.32 g/cm³, while particle density values varied between 2.39–2.71 g/cm³. Soil porosity ranged from 48.84% to 63.97%, whereas soil moisture content fluctuated between 0.43% and 5.20%. The soil colour of the collected samples varied from light brown and dark brown to grey and light green.
Keywords: Soil Spatial Modelling, Physical Properties, Moisture Content

INTRODUCTION

Soil serves as the natural medium in which humans carry out all economic activities, particularly agriculture. It contains essential nutrients for plant growth, and its production, quantity, and quality are influenced by its physical properties. These properties play a crucial role in affecting the chemical and biological characteristics of the soil, as well as its environmental activity, and vice versa, since their relationship is reciprocal. Therefore, these properties are indispensable in any study involving soil and the environment. This study examines selected physical properties of the soil in the study area, compares them, and highlights their impact on plant growth and other soil characteristics.
Do natural and human factors influence the formation of soil physical properties, and how does this affect its quality? Additionally, do these properties vary spatially within the study area?
How do natural and human factors contribute to shaping soil physical properties?
Do soil physical properties exhibit spatial variations within the study area?
Natural and human factors influence the formation of soil physical properties, which in turn affects soil quality. Moreover, these properties vary spatially within the study area.
Natural and human factors significantly impact soil physical properties.
Soil physical properties exhibit spatial variability, which affects soil processes and functions.
The study aims to examine the physical properties of soil in the study area and analyse its spatial variability using spatial modelling through Geographic Information Systems (GIS). Additionally, it seeks to identify the geographical factors influencing these physical properties and their impact on other soil characteristics and environmental activities.
Administratively, the study area is located within the provinces of Muthanna, Dhi Qar, and Diwaniyah, covering a total area of 1,618.44 km². Geographically, it extends between latitude 31°17' and 31°46' north and longitude 45°15' and 46° east.
Naturally, the area lies within the southern part of the Iraqi alluvial plain. It is bordered to the north by alluvial lands, to the west, south, and southwest by the Eastern Euphrates Drain and the Euphrates River, and to the east and southeast by the Main Outfall Drain. See Map (1) for the study area.

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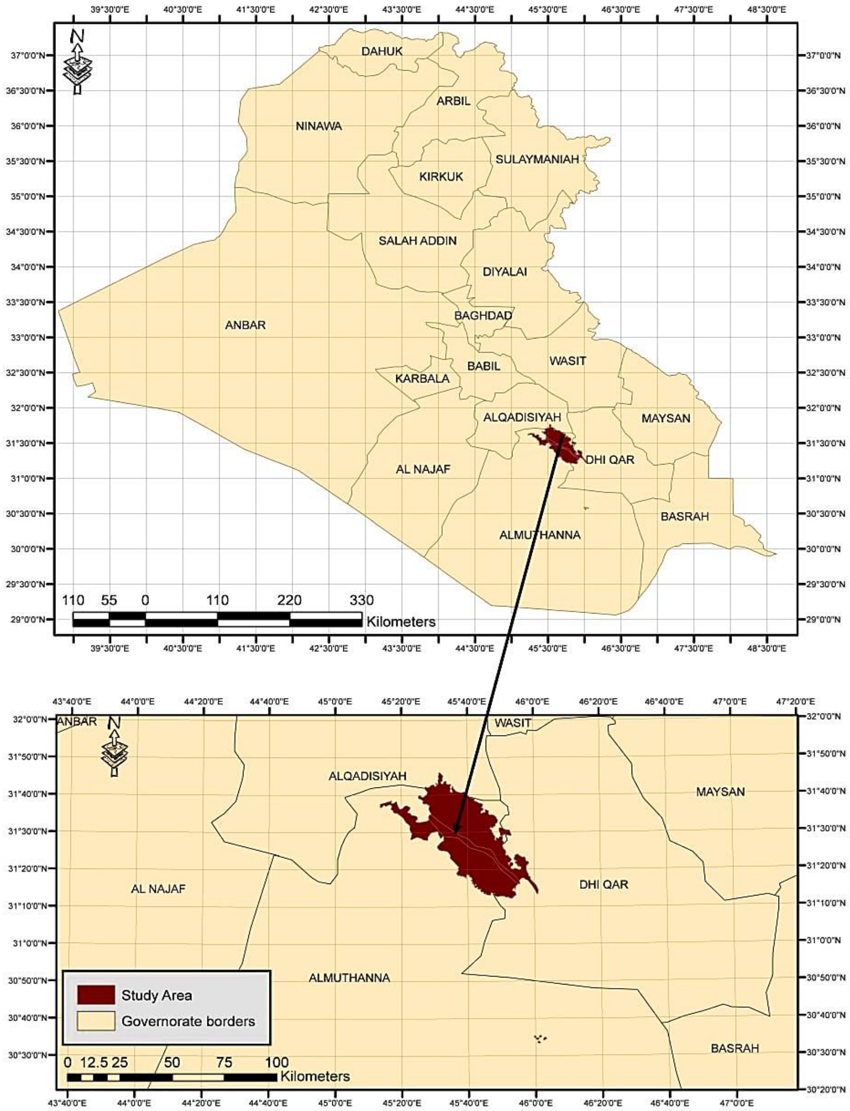
Map (1): Geographical location of the study area



Source: Researcher's work based on the administrative map of Iraq at a scale of 1/1000000 using Arc GIS 10.7.2

2. NATURAL CHARACTERISTICS

A. Geology of the Study Area

The geological nature of an area plays a crucial role in determining soil characteristics and shaping its features. The study area is part of the alluvial plain within the unstable continental shelf, characterized by Quaternary (Holocene) deposits. The following is an overview of the major sedimentary formations in the study area:

Anthropogenic Deposits (Human-Induced Sediments) These deposits are scattered across various parts of the study area and are associated with the remnants of irrigation canals, mounds, and archaeological sites. Notable historical sites include Nippur and the remains of the ancient city of Isin in Afak, located in Al-Qadisiyyah Governorate to the north of the study area. Additionally, the Uruk and Al-Khidir archaeological sites in Al-Muthanna Governorate, along with mounds such as Tell Sankara, Tell Sukkana, and Tell Shawash in Dhi Qar Governorate, are key features. These deposits cover an area of approximately 65.38 km², accounting for 4.0% of the total study area (see Table 1).

Sand Flats and Sand Dunes

These formations appear mainly in the central parts of the study area, typically in the form of barchan dunes (crescent-shaped dunes), which result from aeolian (wind-driven) sedimentation. The sand dunes cover an estimated 22.41 km², or 1.4%, of the study area, while sand flats extend across 449.85 km², representing 27.8% of the total area.

Floodplain Deposits

Dominating the majority of the study area, floodplain deposits mainly consist of silt and fine to medium-grained sand, typically grey to brown in colour. Clayey silt is also present in the upper layers of the alluvial plain (Al-Asadi, 2011, p.19). These deposits span approximately 837.69 km², constituting 51.8% of the total study area (see Table 1).

Shallow Depression Deposits

These deposits are found in very limited quantities, primarily concentrated in the northern part of the study area. The depressions are covered with silty deposits, sand, and clay, with fine shell fragments and gastropod remains being the dominant sediment types (Al-Wahid, 2017, p.33). These deposits cover only 2.45 km², accounting for 0.1% of the total study area.

Dry Marsh Deposits

These deposits are located in the southeastern and northwestern parts of the study area. They are distinguished by their dark grey or black colour, resulting from decomposed plant remains and organic materials mixed with clay. Dry marsh deposits cover an estimated 231.30 km², making up 13.3% of the total study area.

Active Marsh Deposits

These deposits are concentrated in the southern part of the study area. They primarily consist of fine shell fragments, gastropods, and various organic materials. Due to the high organic content, these sediments are extremely fine-grained, giving marsh soils their characteristic black colour. Active marsh deposits cover an area of 9.35 km², accounting for 1.6% of the study area.

Table (1) Area and percentages of sedimentation in the study area.

Deposits	Area (km²)	Percentage (%)
Urban Deposits	65.38	4.0
Sand Flats	449.85	27.8
Sand Dunes	22.41	1.4
Floodplain	837.69	51.8
Shallow Depressions	2.45	0.1
Dry Marshes	231.30	13.3
Active Marshes	9.35	1.6
Total	1618.44	100

Source: Researcher based on ARC GIS 10.7.2

CLIMATIC CHARACTERISTICS

Climate is a key natural factor that directly and indirectly influences soil formation and its physical properties. There is a strong correlation between soil types and climatic conditions, with precipitation and temperature being the most influential climatic elements in soil formation.

The study area is characterized by high temperatures throughout the year, along with a significant thermal range between maximum and minimum temperatures, as well as between summer and winter. The annual average temperature recorded at the meteorological stations in Diwaniyah, Nasiriyah, and Muthanna is 25.1°C, 26.5°C, and 25.1°C, respectively (Ministry of Transport and Communications, 2023).

The prevailing wind system in the study area is the north-westerly wind, with a recorded frequency of 15%, 19.1%, and 23.7% at the Diwaniyah, Nasiriyah, and Samawah stations, respectively. This is followed by westerly winds, which occur at 2%, 7.8%, and 2.4% at the same stations (Ministry of Transport and Communications, 2023).

Regarding wind speed, the annual average wind speed is 3.3 m/s, 3.4 m/s, and 1.9 m/s at the Diwaniyah, Nasiriyah, and Muthanna stations, respectively (Ministry of Transport and Communications, 2023).

Impact of Wind and High Temperatures

Strong winds and high temperatures contribute to soil degradation, particularly through desiccation and wind erosion. This process is particularly significant in areas where fine clay and sandy particles are lifted from fragile soil layers, leading to increased erosion (Abdullah Sabar Aboud, 2014, p. 574).

4. HUMAN CHARACTERISTICS

Population

The population plays a significant role in shaping soil characteristics within the study area. Currently, the region is experiencing population decline due to desertification, particularly the spread of sand dunes, sandstorms, and dust storms. Despite its geographical location between the Euphrates River and the Gharraf River, which makes it resemble a peninsula, the area suffers from severe drought due to a lack of water resources, particularly in the last thirty years. As a result, many residents who once lived in the region have migrated elsewhere.

Today, only a few villages remain in the study area, the most notable being Sheikh Mohammed Al-Ajeel village, which is home to one of the Bedouin tribes that have historically inhabited the region. In addition, there are nomadic Bedouin groups who migrate seasonally and leave the area when water and pasture resources become scarce.

Agricultural Practices

One of the most common agricultural practices in the study area is soil tillage, which involves turning the soil to alter its structure and composition (Al-Qarra Ghouli, 2020, p. 46). This practice has both direct and indirect effects on the physical and chemical properties of the soil. Tillage helps mix fertilizers and organic matter into the soil, enhancing its nutrient content and supporting plant growth. Additionally, it stimulates microbial activity, which plays a crucial role in decomposing organic matter and releasing essential nutrients for plant uptake.

Another agricultural practice in the study area is fallowing, a method where one part of the land is cultivated while another part is left uncultivated. In the first year, a section of the land is planted while the other remains fallow. In the second year, the roles are reversed: the previously cultivated land is left fallow, and the fallow land from the previous year is cultivated.

Irrigation

Irrigation is a fundamental pillar of agricultural production in the study area due to the scarcity and seasonality of rainfall and its annual variability.

The most common irrigation method in the study area is surface irrigation, particularly flood irrigation. This method is widely used, especially in areas irrigated by gravity flow from projects built along the Euphrates River and its tributaries. In these systems, river channels and their branches are naturally elevated above adjacent farmland, allowing water to flow downward by gravity to irrigate nearby agricultural lands.

Another irrigation technique used in the region is basin flooding, where water is directed into the field from one side of the irrigation canal without barriers or levees to regulate flow. This technique requires land levelling and soil smoothing to ensure uniform water distribution.

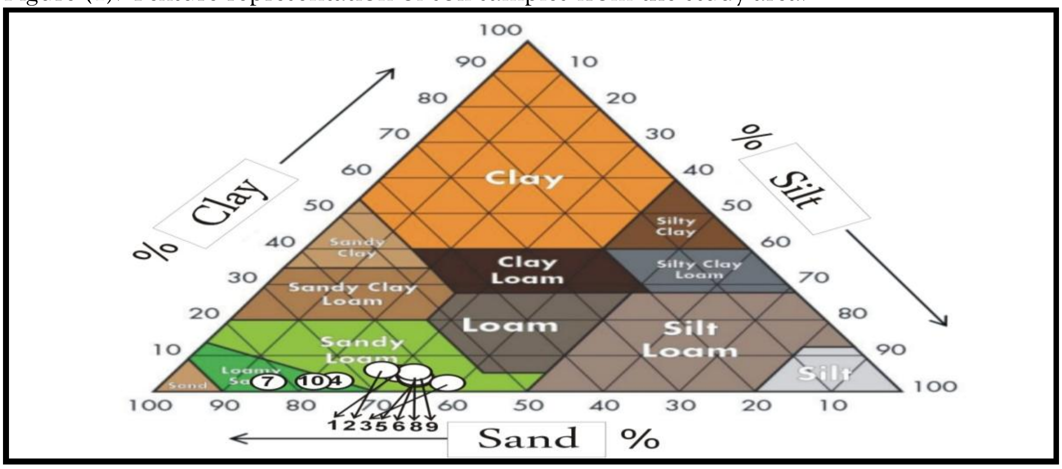
The physical and chemical properties of soil are significantly affected by irrigation practices. Excessive water use can leach nutrients, organic matter, and fertilizers from the soil, depleting its fertility. Moreover, excessive irrigation contributes to rising groundwater levels, leading to waterlogging and other issues, the most serious of which is salinization caused by water evaporation, particularly during the summer months (Al-Omrani, 2004, p. 87).

Physical Properties of the Study Area

A- Texture: Soil texture is defined as the volumetric relationship of soil particles, which indicates the fineness or coarseness of soil particles, and more precisely, the relative proportion of sand, silt, and clay (Shahla Dhakir Tawfiq, 2006, p. 76). Soil texture generally does not include very coarse materials with particles larger than 2 mm in size.
The importance of texture lies in its ability to determine the physical, chemical, and biological properties of the soil, including attributes such as aeration, porosity, water permeability, the soil's capacity to retain moisture, and its suitability for root growth and penetration to absorb water and essential nutrients for plant growth (Saad, 2016, p. 62). Soil texture is determined by two methods: the field method, which is less accurate and involves feeling the particles, and the laboratory method, which is more accurate and involves determining the percentage of sand, silt, and clay through mechanical analysis of soil samples (Al-Mashhadani, 2006, p. 64).
Based on the laboratory results obtained from soil samples taken from the study area, as shown in Table (2) for the depth (0-30) cm, it was found that there are two types of soil. The first type is sandy loam, which is the predominant soil type in the study area and appeared in samples (1, 2, 3, 5, 6, 8, 9). This soil is considered good due to the high proportion of clay compared to sand. A characteristic of this soil is that it warms quickly in spring. To maintain its fertility, lime and fertilizers must be added periodically. This type of soil is suitable for growing vegetables, fruits, and grains.
The second type is loamy sand, which was represented in samples (4, 7, 10). It has a higher proportion of sand, which is accompanied by increased permeability, larger particles, and greater pore spaces. This makes the soil easier to plow and subsequently plant. It is recommended to add some amendments to this type of soil and mix it with other components to improve its quality and increase its productivity, as shown in Map (2).
Table (2): Laboratory analysis results of soil texture % for samples from the study area

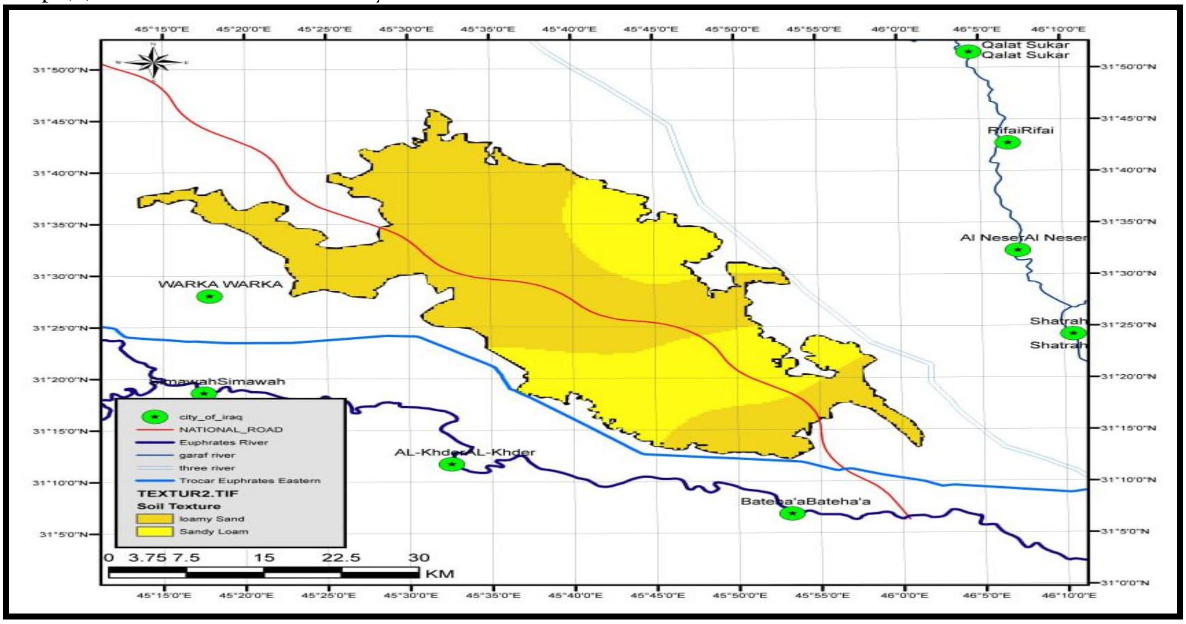
Sample	Depth (cm)	Sand Texture (%)	Silt Texture (%)	Clay Texture (%)	Texture Class
1	0-30	65.32	30.11	4.27	Sandy Loam
2	0-30	66.30	27.42	5.21	Sandy Loam
3	0-30	60.29	37.74	1.92	Sandy Loam
4	0-30	75.19	22.94	1.86	Loamy Sand
5	0-30	64.69	33.43	1.86	Sandy Loam
6	0-30	64.61	33.43	1.94	Sandy Loam
7	0-30	83.65	21.27	4.06	Loamy Sand
8	0-30	66.64	31.66	1.69	Sandy Loam
9	0-30	66.50	31.30	1.85	Sandy Loam
10	0-30	77.22	18.96	3.80	Loamy Sand

Source: Researcher's work based on the results of laboratory analysis of soil samples from 2024 at the UsainScience Laboratory, Diwaniyah Governorate, licensed and registered with the Iraqi Chemists Syndicate No. (N, 116).
Figure (1): Texture representation of soil samples from the study area.



Source: Researcher's work based on Table (2)

Map (2): Soil texture in the study area



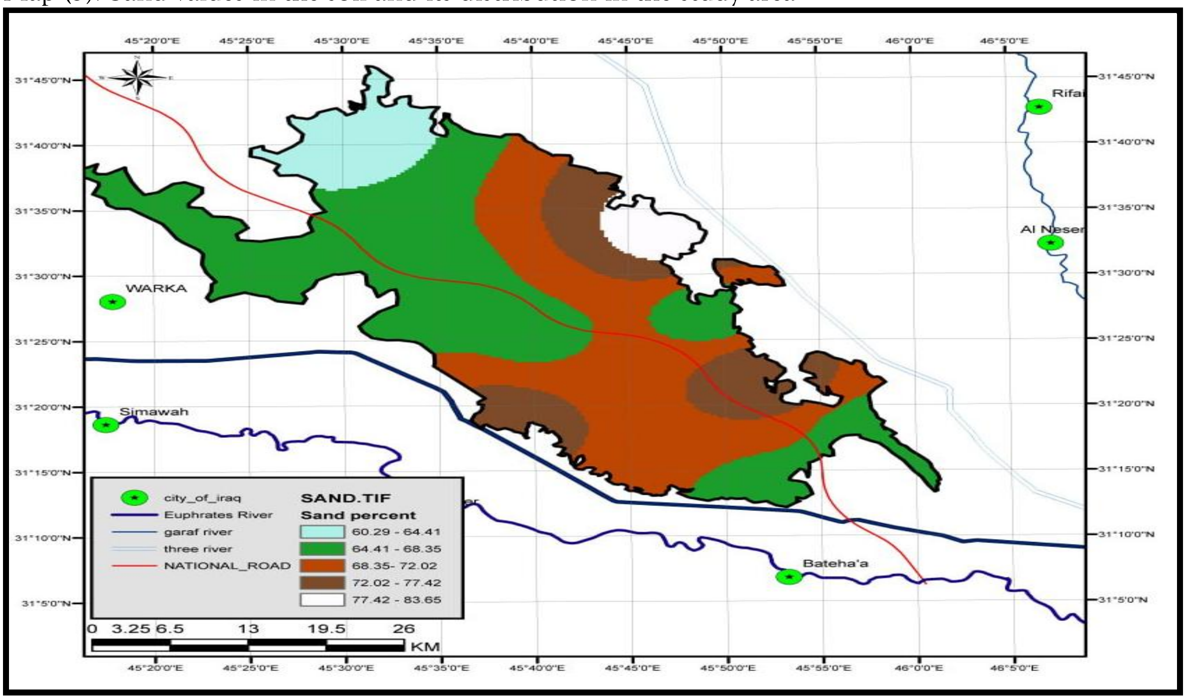
Source: Researcher based on Arc Gis 10.7.2

One of the main types of soil textures is:

1- Sandy Texture: After conducting laboratory analysis of the samples collected from the region, the results shown in Table (2) and Map (3) for the depth (0-30) cm were classified into five categories. There is a variation in the percentage of sand in the soils of the study area. In the first category, the percentage ranged between 64.41% and 60.29%, represented by sample (3), which had a value of 60.29%. The percentage then increased, reaching between the values in the fourth category (77.42% - 72.02%) for samples (4, 10), with percentages of 77.2% and 75.19%, respectively. The highest percentage fell within the fifth category (83.65% - 77.42%) in sample (9) with a percentage of 83.65%.

The reason for the high percentage of sandy texture is attributed to two factors: the geological factor of the region, which is dominated by deposits of sand dunes and sandy sheets, and the climatic factor, which plays a significant role through the high temperatures. These conditions cause the outer soil layer to dry out, leading to processes of erosion, transport, and wind deposition. This is illustrated in Figure (1).

Map (3): Sand values in the soil and its distribution in the study area



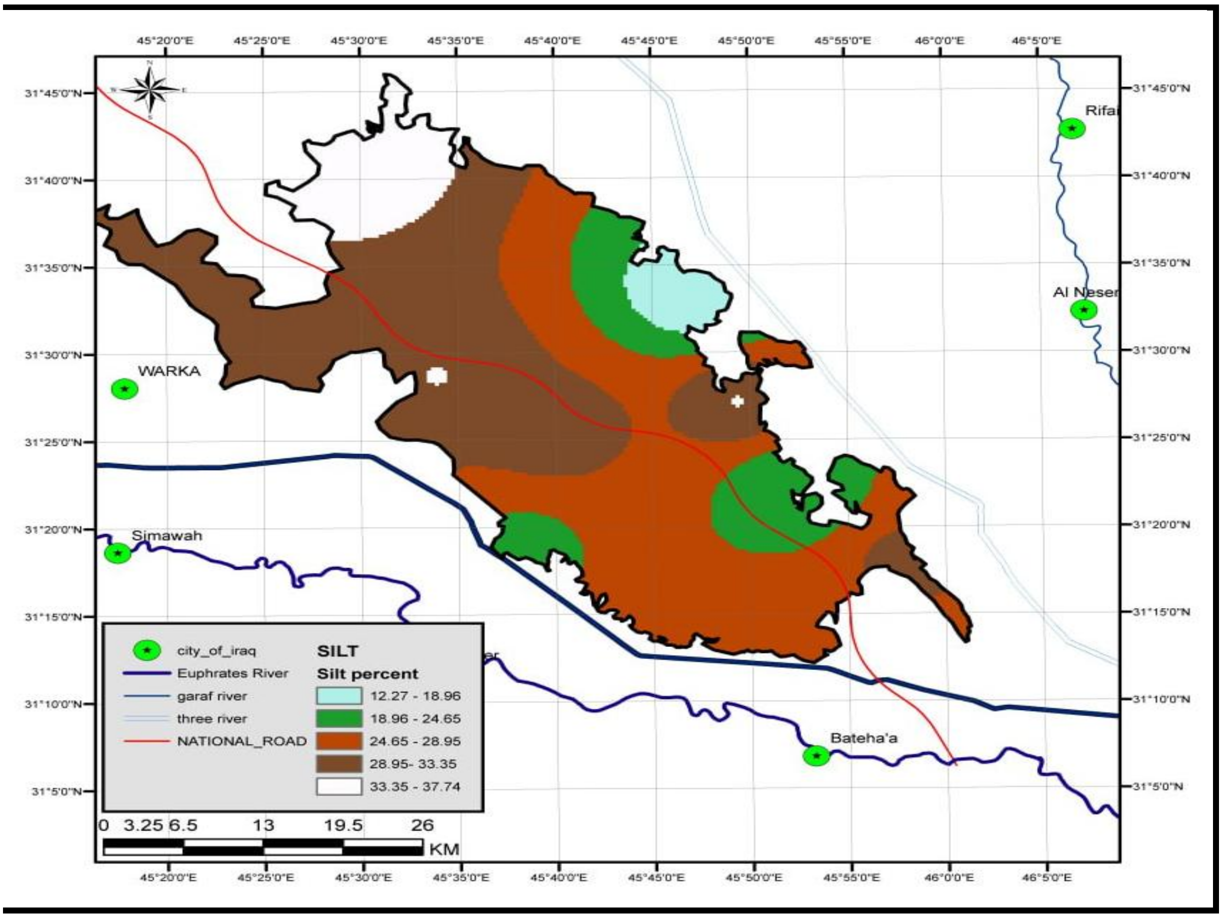
Source: The researcher based on the results of laboratory analyses using Arc GIS 10.7.2 program.

2- Silty Texture:

There is a variation in the percentage of silt in the soils of the study area, as shown in Table (2) and Map (4) for the depth (0-30 cm), which is divided into five categories. The lowest silt percentage is found between the two categories (18.96% - 12.27%), represented by samples (7, 10) with percentages of 18.96% and 12.27%, respectively. This decrease can be attributed to the high percentage of sand and the low amounts of rainfall and the sedimentary deposits formed as a result.

The silt content then increases, reaching the third category (28.95% - 24.65%), represented by sample (2) with a percentage of 27.42%. The highest silt percentage is found in the fifth category (37.74% - 33.35%), represented by samples (5, 6, 3) with percentages of 37.74%, 33.43%, and 33.43%, respectively. This is illustrated in Figure (1). The increase in silt can be explained by the natural conditions accompanying the formation of the deposits during the Quaternary geological period, as well as the sediments from the Al-Gharaf and Euphrates rivers.

Map (4): Silt values in the soils of the study area



Source: The researcher based on the results of laboratory analyses using Arc GIS 10.7.2 program.

3- Clay Texture:

As shown in Table (2) and Map (5) for the previously mentioned depth, the clay percentages are relatively consistent. The lowest values are found between the first category (2.26% - 1.69%), which appear in samples (3, 4, 5, 6, 8, 9) with percentages of (1.92%, 1.86%, 1.86%, 1.94%, 1.69%, 1.85%) respectively. The highest values were recorded within the category (5.21% - 4.19%) in samples (1, 2), with percentages of (4.27%, 5.21%) respectively.

This decrease in clay content can be explained by the high percentage of sand in these soils, as well as the nature of the rocks from which they are derived.

Map (5): Clay values in the soils of the study area

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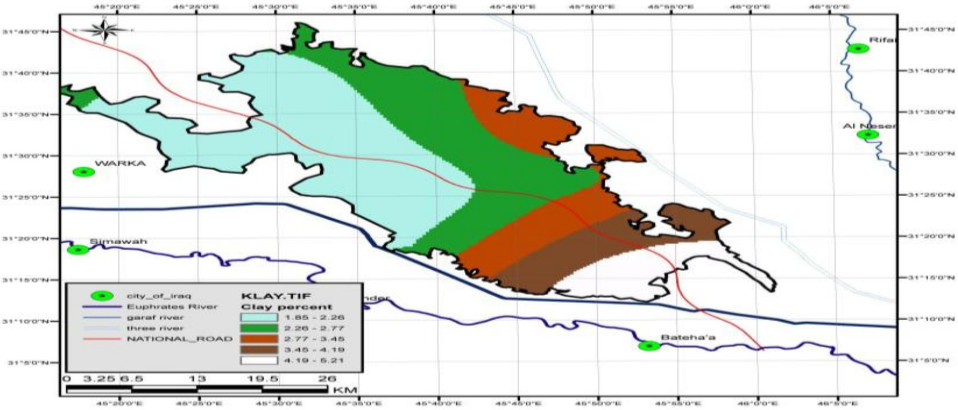


Source: The researcher based on the results of laboratory analyses using Arc GIS 10.7.2 software.

Second: Bulk Density:

Bulk density is the mass of a unit volume of dry soil, which includes both the solid part of the soil and the pores. It is measured in grams per cubic centimetre (g/cm³) or micrograms per cubic centimetre (µg/cm³) (Foth, 1984: p. 36). The study of bulk density is significant, particularly in irrigated soils, as it affects the soil's water conductivity and its ability to retain water. An increase in the soil's moisture content generally reduces its bulk density. It also plays a crucial role in determining soil porosity, which dictates the movement of water and air within the soil (Reeve, 1973: p. 67). Moreover, when bulk density increases, root penetration decreases, which negatively impacts plant health. Additionally, the reduction in the diversity of soil microorganisms affects organic decomposition and nutrient cycling.

Table (3): Bulk Density Percentages According to Soil Types

Types of soils	Bulk density ratio
Sandy soils	1.5- 0.9
Sandy soils - clay loose	1.2-1.1
Sandy soils – heavy clay	1.4-1.3
Light clay soils	1.5-1.4
Medium clay soils	1.6- 1.5
Heavy clay soils	1.7- 1.6

(Kamal Sheikh Hussein, 2012, p. 50)

Factors Affecting Bulk Density:

The organic matter content in the soil affects the bulk density, as the bulk density value decreases with an increase in organic matter content.

There is an inverse relationship between bulk density and soil porosity; porosity increases as bulk density decreases.

The soil texture also affects bulk density. For example, the bulk density of sandy soils ranges between 1.2 and 1.8 g/cm³, while for clayey soils, it ranges between 1.5 and 1.6 g/cm³ (Al-Hadi, 2005, p. 64), as shown in Table (3).

Table (4): Physical Properties of Soil Samples in the Study Area

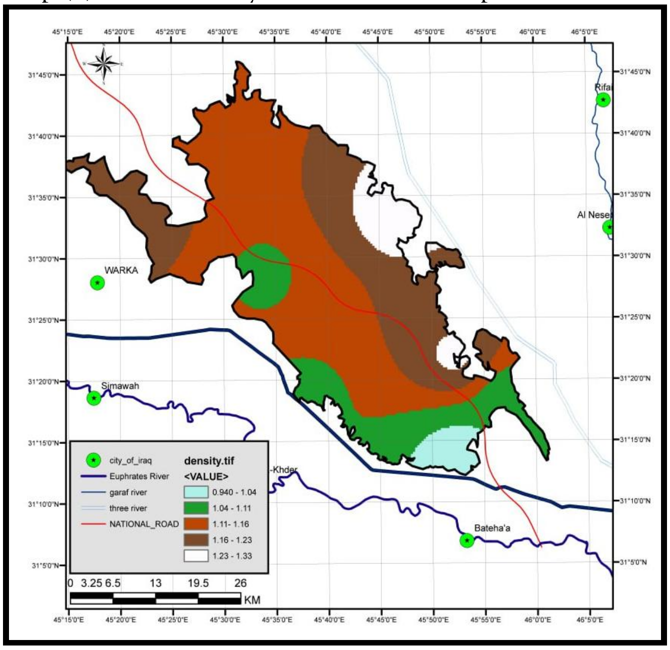
Color	Humidity%	Porosity %	True density g/cm3	Bulk density g/cm3	Depth/cm
gray	2.10	58.75	2.57	1.06	30-0
gray	0.64	63.97	2.61	0.94	30-0
Light Brown	0.43	53.13	2.39	1.12	30-0
gray	3.47	54.73	2.43	1.10	30-0
Light Green	5.20	55.14	2.71	1.22	30-0
Light Brown	3.36	55.82	2.49	1.10	30-0

Dark Brown	1.57	48.84	2.60	1.33	30-0
Light Brown	2.20	57.89	2.66	1.12	30-0
gray	2.09	54.47	2.68	1.22	30-0
Light Brown	3.39	49.80	2.51	1.26	30-0

Source: Researcher's work based on the results of laboratory analysis of soil samples for the year 2024 in the Usain Science Laboratory, Diwaniyah Governorate, licensed and registered in the Iraqi Chemists Syndicate No. (N, 116).

From the data presented in Table (4) and Map (6) for the depth (0-30) cm, a variation in the bulk density values is observed. The lowest value for bulk density falls within the range (1.04–0.94), represented by sample (2) with a value of (0.94). Subsequently, the bulk density values increase, with values ranging from (1.16–1.11) in samples (3, 8) at (1.12) each. As for the highest bulk density values, they were observed in samples (7, 10), with values falling within the range (1.33–1.23), at (1.33) and (1.26), respectively. This variation is attributed to the distribution of soil particle sizes, including sand, silt, and clay. Additionally, increased plowing and the addition of organic fertilizers contribute to the reduction of bulk density.

Map (6): Bulk Density Ratios in Soil Samples from the Study Area



Source: The researcher based on data from Table (4) and Arc GIS 10.7.2 program.

Thirdly - The True Density of Soil: The true density of soil represents the mass per unit volume of the soil particles, excluding the pores between them (Henry, 1990, p.31). Its values depend on two factors: the first is the mineral composition, which includes the presence of iron oxides and heavy metals that increase the true density of the soil; the second is the organic matter, where an increase in organic material results in a lower true density. The importance of true density lies in determining the soil's porosity, its mineral composition, and its organic matter content.

From the previously mentioned Table (4), it can be observed that the true density values vary slightly among the soil samples from the study area. The first category (2.47–2.39) g/cm^3, which includes samples (3, 4), had values of (2.39, 2.43) g/cm^3, respectively. Then, the values increase to reach the third category (2.58–2.53) g/cm^3 in sample (1), with a value of (2.57) g/cm^3. This value is lower than the optimal true density value of (2.65) g/cm^3, which is considered ideal for good soils. As for the highest values, they were recorded in the fifth category (2.71–2.63) g/cm^3, in samples (9, 8, 5), with values of (2.66, 2.68, 2.71) g/cm^3. These are moderate values for the true density in the soils of the study area, attributed to the balance between the true density and the organic material content in these soils.

Map (7): True Density in the Soils of the Study Area

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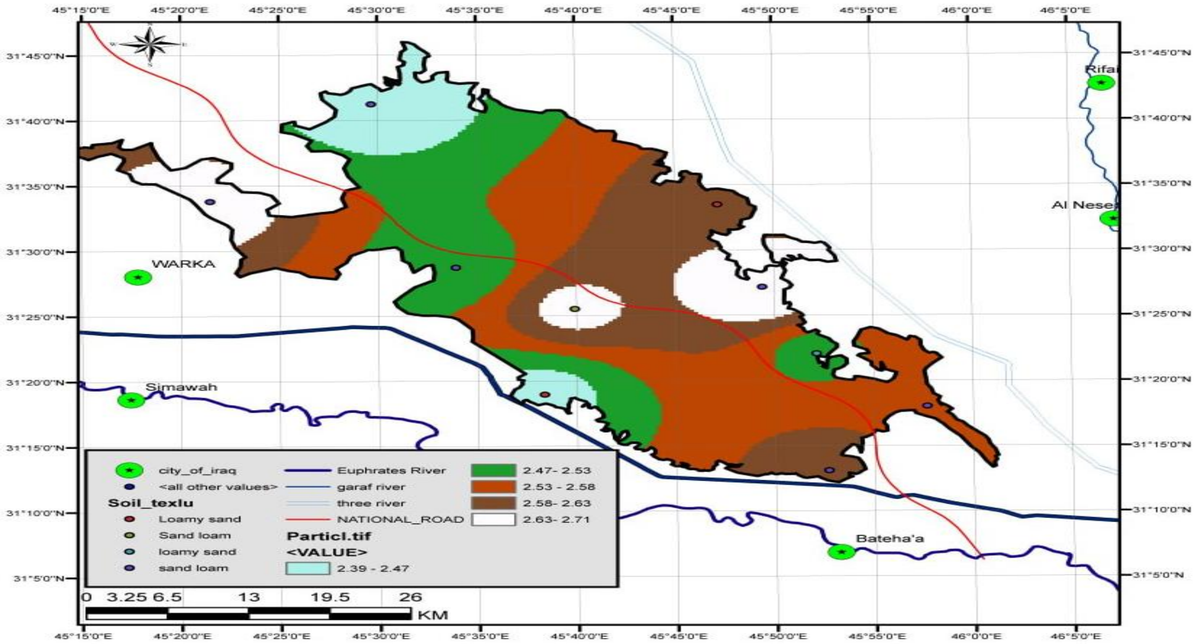


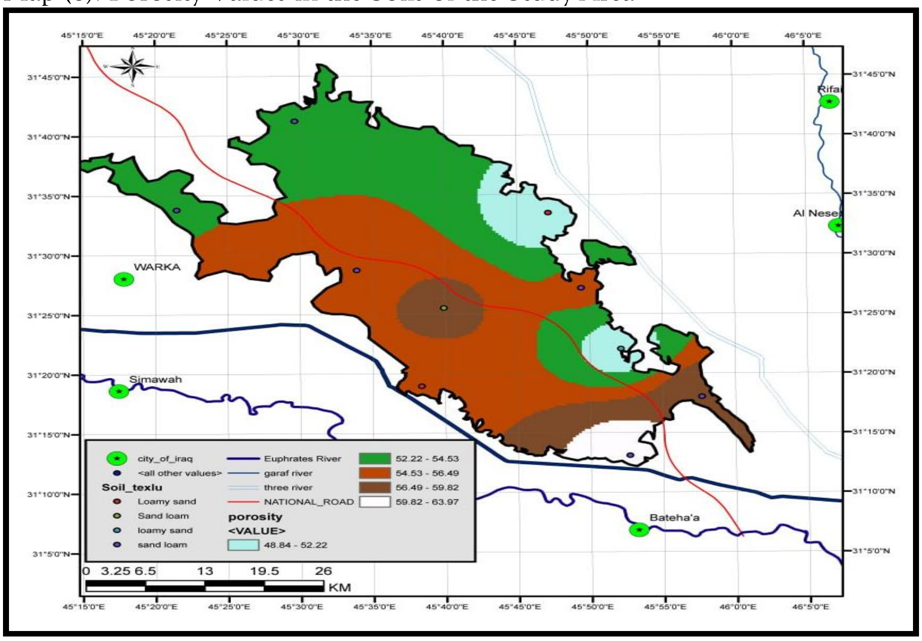
Source: Researcher's work based on data from Table (4) and ARC GIS 10.7.2 program.

Fourthly - Soil Porosity: Soil porosity is the ratio between the volume of pores filled with both water and air and the total volume of the soil. It is used as a relative indicator of the volume of voids present in the soil (Al-Mousawi, 2005, p. 104). The study of soil porosity is essential to understand the volumetric distribution of its pores. Based on this, two types of pores can be distinguished:

Capillary Pores (Inactive Pores): These are small pores with diameters less than 8 microns, which allow water to drain.

Active Pores: These are larger spaces with diameters greater than 8 microns, containing both air and water as well as various organisms. They play a crucial role in soil aeration and internal drainage (Nahal, 1960, p. 108).

Map (8): Porosity Values in the Soils of the Study Area



Source: Researcher's work based on data from Table (4) and ARC GIS 10.7.2 program.

Fifthly - Soil Moisture: Soil moisture, also known as moisture content, represents the percentage of the weight of water relative to the weight of solid particles in a soil sample. Soil moisture varies depending on influencing factors, such as the soil's granular and chemical composition and the size of its pore spaces. The finer the soil texture, the higher its moisture retention (Fouad Al-Kurdi, 1976, p. 56).

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From the data in Table (4) regarding the spatial variation of soil moisture at the depth (0-30 cm), it is observed that the lowest values were found within the ranges (1.49-0.43) in samples (2,3), with values of (0.64, 0.43) %, respectively. Then, the moisture values increase within the ranges (2.34-1.49) in samples (1,7,8,9), which recorded values of (2.10, 1.57, 2.20, 2.09) %. As for the highest values at the same depth, they reached (5.21%) in sample (5) within the range (5.20-3.82).

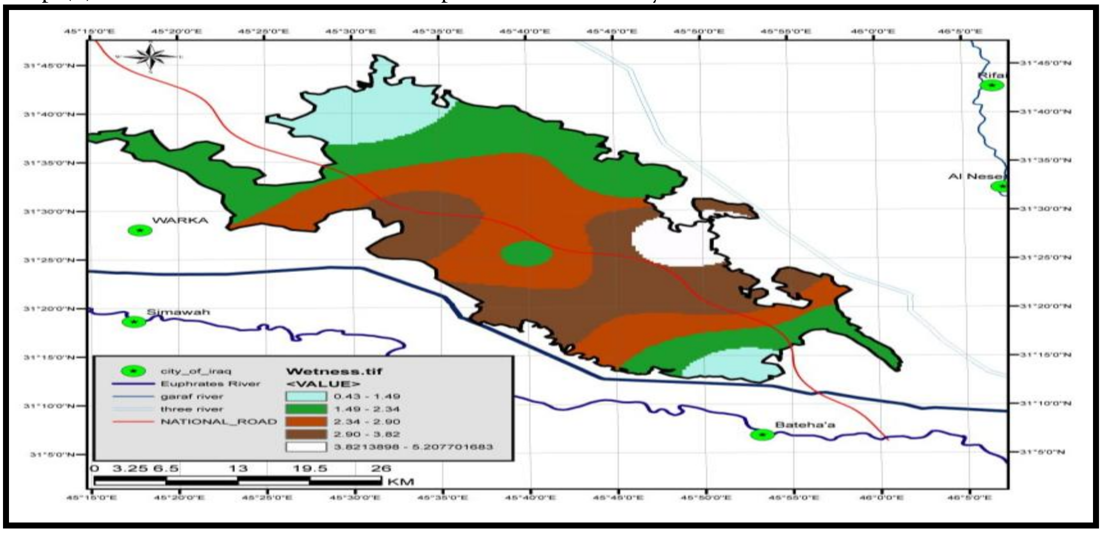
As seen from the table (5), which shows the ready water percentage available to plants in the soil, it is evident that the moisture content in the soil is quite low to moderate. This low moisture content is attributed to the prevailing natural conditions, including high temperatures, low precipitation, and limited organic matter that helps retain moisture in the soil. Additionally, the chemical composition of salts present in the soil solution contributes to the reduction of moisture content in the soil.

Map (9): Available Moisture in Soil Samples

Partition	Percentage of ready-made water for the plant
Very few	Less5%
A little	10-5%
medium	15 -10.1%
high	20 -15.1%
Very good	More than 20%

(Laith Khalil Ismail, 1999, p. 105).

Map (9): Moisture content in soil samples from the study area



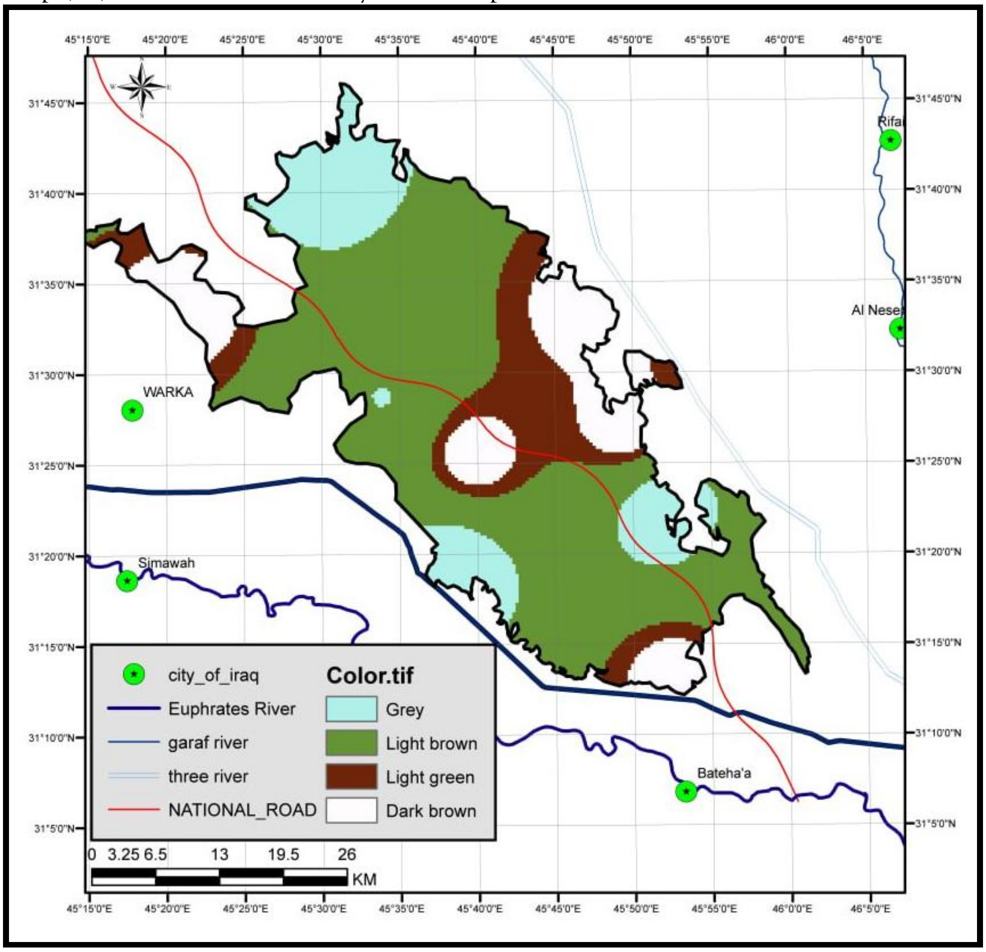
Source: Researcher's work based on data from Table (4) and ARC GIS 10.7.2 program.

Sixth - Soil Colour: Soil colour is one of the most distinguishing and visible characteristics of soil to the naked eye, often reflecting various other natural soil properties. The colour of soil depends on several factors, including the rock fragments and minerals present in the soil (parent material), the moisture content of the soil, the amount and type of organic matter, and the characteristics of each organic material (Abdullah Najm Alani, 1980, p. 59).

Soil colour indirectly affects plant growth by influencing temperature changes. It can also indicate moisture levels and the presence of organic matter, which affects the availability of nutrients for plants. However, soil colour alone should not be relied upon to determine soil fertility or productivity; understanding the soil's key properties is essential. In many cases, soil colour reflects the mineral and organic components it contains (Al-Shalash, 1985, p. 63).

From the data in Table (4) for the depth (0-30 cm) and Map (10), it is evident that the colours of the soils in the study area vary among the samples. The grey colour is present in samples (1, 2, 4), and this is attributed to low vegetation cover, as well as the soil's origin from rocks rich in calcium deposits, salts, and minerals like quartz and feldspar, which result from the removal of iron. The light green colour appeared in sample (5) and is associated with herbs and small plants, as well as organic matter, indicating microbial activity. Other samples with a light brown colour (samples 3, 6, 8, 10) indicate low organic content in the soil. As for samples (7, 9), they show a dark brown colour due to their richness in organic materials.

Map (10): Soil Colores in Study Area Samples



Source: Researcher's work based on data from Table (4) and ARC GIS 10.7.2 program.

CONCLUSIONS

This study reached the following conclusions:

Natural and Human Factors: Natural and human factors have significant impacts on the variation of soil physical properties. It was observed that geological deposits had a clear influence on the formation of the parent material of the soils in the study area. This is through their interaction with climatic properties and other factors. As for the climatic conditions, the high temperatures had a clear effect on increasing evaporation rates, leading to salt accumulation. Additionally, the irregular rainfall and the impact of winds, which caused soil erosion and the spread of sand dunes, also had notable effects.

Human Influence: Human activities, especially agricultural practices and irrigation systems, influence soil properties, particularly physical characteristics like soil texture and bulk density.

Soil Texture: There is a variation in soil texture in the samples from the study area due to the soil fractions. These textures ranged between sandy loam and loamy sand.

Bulk Density and True Density: The bulk density ranged between (0.94–1.32 g/cm^3), and true density varied within a small range between (2.39–2.71 g/cm^3).

Soil Porosity: The area under study generally has medium to good porosity.

Soil Moisture: The soil moisture in the study area is very low to low, mainly due to prevailing natural conditions, including high temperatures, low precipitation, and a low level of organic matter.

Soil Colour: There is variation in soil colour, with light brown being the predominant colour, transitioning to grey, dark brown, and light green.

Recommendations:

Soil Improvement: Increase attention to soil by adding organic matter, such as animal and plant residues.

Sustainable Agricultural Practices: Introduce crop rotation systems and reduce soil compaction from machinery to improve soil quality. Additionally, soil should be covered with vegetation to prevent erosion and degradation.

REFERENCES

1. Ismail, Laith Khalil. (1999). Irrigation and Drainage, Dar Al-Kutub Publishing and Printing, Mosul, p. 105.
2. Hussein, Kamal Al-Sheikh. (2003). Geography of Soils, 1st edition, Dar Al-Manhal Al-Lubnani, Ras Al-Nabeh Library for Printing and Publishing, Beirut, Lebanon, p. 50.
3. Saad, Kazem Santha. (2026). Geography of Soils, College of Education, University of Maysan, p. 62.
4. Al-Shalash, Ali Hussein. (1981). Geography of Soils, 2nd edition, Basra, p. 77.
5. Alani, Abdullah Najm. (1980). Principles of Soil Science, 1st edition, Baghdad, p. 59.
6. Nahal, Ibrahim Nahal. (1964). Soil Fundamentals, University Press, Alexandria, p. 108.
7. Al-Hadi, Yusuf Mohammed. (2005). Earth and Water Sciences, 1st edition, College of Agriculture and Sciences, University of Jerash, p. 64.
8. Al-Asadi, Wala Kamil Sabri Hussein. (2008). Hydrogeomorphology of the Euphrates River Between Al-Khidr and Al-Qurna, PhD thesis, College of Arts, University of Baghdad, p. 19.
9. Alani, Shahla Thakra Tufiq. (2006). Spatial Relationships of Soil Salinity and Texture in Agricultural Land Use in Wasit Governorate, PhD thesis, College of Education ibn Rushd, University of Baghdad, p. 76.
10. Al-Omrani, Adel Rahi. (2004). Land Use Change for Cereal Crops in Al-Qadisiyyah Governorate (2010-2021) Using GIS, master's thesis, College of Arts, University of Al-Qadisiyyah, p. 87.
11. Al-Qara Ghooli, Duaa Faleh Hassan. (2020). Geographic Analysis of Soil Characteristics in Al-Shatra District, master's thesis, College of Arts, University of Basra, p. 46.
12. Al-Mashhadani, Niran Ali Hassan. (2006). Soil Characteristics and Classification in Al-Muqaddadiya District, master's thesis, College of Education, University of Diyala, p. 64.
13. Al-Mousawi, Nasir Abdul Sajad Abdul Hassan. (2006). Spatial Variation of Soil Characteristics in Basra Governorate, PhD thesis, College of Arts, University of Basra, p. 104.
14. Al-Wahid, Hussam Kanan Wahid. (2017). Spatial Analysis of Medicinal Plants in Al-Samawah Desert and Their Investment Potential, PhD thesis, College of Arts, University of Baghdad, p. 33.
15. Al-Ajili, Abdullah Sabbar Aboud. Geological and Hydrological Characteristics of the Desert Depressions (Floodplains) in Southern Iraq Plateau and Their Economic Potential, Al-Ustadh Journal, Vol. 1, p. 574.
16. Ministry of Transport and Communications, General Authority for Meteorology and Seismological Monitoring, Climate Division, unpublished data, 2023.
17. Foth, Henry. (1984). Fundamentals of Soil Science, 7th edition, U.S.A, p. 36.
18. Foth, Henry D. (1990). Fundamentals of Soil Science, 8th edition, John Wiley & Sons, New York, U.S.A, p. 31-32.
19. Reeve, M. J., et al. (1973). The Effect of Density on Water Retention Properties of Field Soil, Sci. Soc. Amer. Proc., p. 67.