University of Baghdad
College of Engineering
JE
JOURNAL OF ENGINEERING

# Journal of Engineering

journal homepage: www.joe.uobaghdad.edu.iq

Volume 29 Number 9 September 2023

# Mechanical and Physiochemical Properties of Central Marshes Bed Soils – Southern Iraq

**Riyam Riyadh Kareem[1], Zuhair Kadhim Jahanger [2,*]**

Department of Water Resources Engineering, College of Engineering, University of Baghdad, Baghdad, Iraq
riyam.karam2010m@coeng.uobaghdad.edu.iq[1], zk_jahanger@coeng.uobaghdad.edu.iq[2]

## ABSTRACT

The central marshes are one of the most important wetlands/ecosystems in the southern area of Iraq. This study evaluates the bed soil's mechanical, physical, and chemical properties at certain southern Iraqi central marshes sites. This was conducted to investigate their types and suitability for enhancing the agricultural reality of most field crops and for construction purposes. Soil samples were collected from 15 sites at 10-100 cm depth. Hence, numerous parameters were determined: index properties, unconfined compressive strength, direct shear strength, consolidation, texture, and sieve analysis, water content, specific gravity, dry density, permeability, pH, total soluble salts (TSS), organic materials (OM) and total sulfate content $SO_3$. Results of this study showed that the bed soil of the Central Marshes is classified as clay-silt soil and suitable for planting different crops. Furthermore, Analysis of the results may have a role in the design and planning of upcoming projects, such as the construction of buildings and agriculture, that would have to enlighten the decision maker.

**Key Words:** Bed soil, Central marshes, Southern Iraq, Geotechnical properties.

*Corresponding author
Peer review under the responsibility of University of Baghdad.
https://doi.org/10.31026/j.eng.2023.09.05
This is an open access article under the CC BY 4 license (http://creativecommons.org/licenses/by/4.0/).
Article received: 10/01/2023
Article accepted: 14/05/2023
Article published: 01/09/2023

# تقييم جودة التربة للأهوار الوسطى في المنطقة الجنوبية من العراق

ريام رياض كريم[1]، زهير كاظم جهان كير[2،*]

قسم هندسة الموارد المائية، كلية الهندسة، جامعة بغداد، بغداد، العراق

**الخلاصة**

الأهوار الوسطى هي واحدة من أهم الأراضي من حيث النظم البيئية في المنطقة الجنوبية من العراق. أجريت دراسة لتقييم جودة التربة من حيث الخواص الميكانيكية والفيزيائية والكيميائية لمواقع معينة في جنوب العراق في الأهوار الوسطى للتحقق من أنواعها ومدى ملائمتها لتعزيز الواقع الزراعي لمعظم المحاصيل الحقلية. جمعت عينات التربة من 15 موقعا لعمق 10−100 سم. عدة فحوصات أجريت في المختبر: خصائص المؤشر، واختبارات قوة الانضغاط غير المحصورة، واختبارات مقاومة القص المباشر، واختبار التوحيد، وتحليل النسيج والغربال، ومحتوى الماء، والجاذبية النوعية، والكثافة الجافة، والنفاذية، ودرجة الحموضة، والأملاح الذائبة الكلية (TSS)، المواد العضوية (OM) ومحتوى الكبريتات الكلي $SO_3$. وأشارت الاختبارات التي أجريت على العينات إلى أنه يمكن القول إن تربة الأهوار الوسطى هي تربة طينية غرينية وكشفت أن معظم أراضي الأهوار الجنوبية صالحة لزراعة المحاصيل المختلفة. قد يكون لتحليل النتائج دور في تصميم وتخطيط المشاريع القادمة مثل البناء والزراعة التي من شأنها أن توضح الصورة لصانعي القرار.

**الكلمات المفتاحية:** تربة قاع الهور، الاهوار الوسطى، جنوب العراق، الخصائص الجيوتقنية.

## 1. INTRODUCTION

Marshes are defined as an area where water has covered the land for centuries and are regarded as a wetland ecosystem. Iraq's Marshes significantly affect economic, social, and biodiversity values. Assessment of the mechanical and physical properties of the soil Mechanical and physical properties are important to hydrology, seepage, construction of buildings and roads, as well as plants. Hence, the new plan regarding the marshes is to invest in the marshes area for different projects such as residential and tourism buildings. The presence of marshes characterizes the southern part of the alluvial plain in Iraq. The low-lying lands are covered by water throughout the year or part of it (**Hammer, 2022**). The marshes are filled with water in the spring season of the Tigris and Euphrates rivers floods, and during the summer, the surplus water flows into the Arabian Gulf **(Al-Mudaffar, 2016; Albarakat et al., 2018; Al-Jasimee et al., 2020, Jasim et al., 2022)**. The marshes are located in Iraq between latitudes 35° 30' and 32° 45' N and between longitudes 13° 46' and 48° 00' E **(Hason et al., 2020)**. The area of the marshes in Iraq reaches 35,000 km$^2$, around 9000 km$^2$, representing a permanent marsh filled and covered with water over the year. Another 9000 km$^2$ is non-permanent marshes filled with water during the rainy season, while the rest is shallow areas and have no water but are covered with Phragmites Australis and Typha domingensis **(Al-Mukhtar and Al-Yaseen, 2019; Salim, 2021)**

The marshes of Iraq are divided into two groups in terms of water supply. The first is the marshes fed by permanent flowing rivers such as the Tigris and Euphrates Rivers, such as the Al-Hawizeh Marshes, the Hammar Marshes, and the central marshes (the Marshes of Al-Qurnah or Al-Gebaysh) and the extinct Horaqarquf marsh. The second group is the marshes that are fed by valleys with the seasonal flow coming from the Iraqi al-Jazirah plateau, the Iraqi desert plateau, or from northern Saudi Arabia, such as the Umm al-Rahhal marsh, al-Rifai marsh, al-Malh marsh, and Abu Debs marsh **(Khidher, 2019; Hasab et al., 2020)**. One of the biggest wetlands in Mesopotamia is the Central Marsh, which consists of small wetlands. The Tigris and Euphrates Rivers form the eastern and southern boundaries of the Central Marshes, respectively. The Central Marshes, spanning around 3000 km$^2$ during the flood season, are situated between Nasiriyah, Maimona, Qalat Saleh, and Al-Qurna. During the typical dry season, the region shrinks to only 600 km$^2$. The Tigris River tributaries in the Ammara governorate serve as the central marshes' primary water supplies. Al-Areed, Al-Bittera, and Al-Majar Al-Kabeer rivers are these tributaries **(Daham et al., 2018; Salim et al., 2020)**.

The soils of Iraqi marshes are a unique type among wetlands and semi-lands for West Asia and the world. They are characterized by unique features even though they deteriorated due to the construction of the Maysan River project, which made it vulnerable to desiccation from 1991 through 2003. This was the largest environmental phenomenon in the Marshlands, which turned to dry lands, and when most of the marshes area residents migrated to the surrounding main cities. Also, the area suffered from large ecosystem changes, in which local animals and plants were reduced to very low levels. Only 10% of the marshland was preserved, 60% became desert, and 30 % was used for agriculture **(Al-Saad and Al-Timari, 1993; Al-Sudani, 2017; Abbas et al., 2018; Hashim et al., 2019)**. In 2010, the Iraqi government tried to return water to the central marshes by constructing a submersible dam on the Euphrates River to raise the water level and divert it to the central marshes **(Nadheer, 2021; Alwan and Aziz, 2022)**. Good knowledge and assessment of marsh soil quality are important for managing and rehabilitating marsh areas **(Al-Suhili and Ghafour, 2013; Marsh et al., 2018)**.

Enhancing soil's mechanical properties and behavior is frequently required to construct and operate various structures safely. The physical characteristics of the soil are of great importance in its agricultural uses, as it is important in the operations of cultivation, irrigation, drainage, management, maintenance of soil and water, and fertilization. The chemical properties of soils vary from one place to another. Detailed descriptions of the marsh-area soil properties are prerequisites of any agricultural, environmental, and engineering projects, which play a vital role in the design and planning of the upcoming projects that would have to enlighten the decision makers.

Many studies dealt with the morphological and taxonomic characteristics of the marsh soils in Iraq. However, studies of the mechanical, physical, and chemical properties of the soils of this environment are still limited. As marshlands are economically important, this study aims to investigate their soil's mechanical, physical, and chemical properties to identify their suitability for construction and agriculture. The problem is studied using field tests and experimental lab approaches to have the best data for the soil bed that is important for the construction procedure of keeping the Marshes investment in the future combating the potential impact of climate change.

## 2. METHODS AND APPARATUS

Central Marshes are a rare and complete ecological system in Iraq's southern region. The region's borders are roughly delineated by a triangle among Nasiriyah, Qal'at Salih, and Qurna. The Tigris River tributaries (Al-Bittera, Al-Areedh, and Al-Majer Al-Kabeer Rivers) are situated on the north side of this area in Amara Governorate. The Euphrates River is situated on the southern side of the Central Marshes, between the Souq-Al-Sheouk and Al-Qurna areas. The Missan (Al-Izz) River is located on the east side, a road connecting the villages of Al-Salam and Al-Islah from the west. This area is located between 675000 and 712386 m Easting and from 3425000 to 3483000 m Northing in zone 38 N, UTM-WGS84. Al-Ghibayish Marsh is the major part of Central Marshes (the middle of Central Marshes), located west of the Tigris and North of the Euphrates River **(Al-Abbawy and Al-Mayah, 2010)**. It collects water from the Euphrates. During floods, the Central Marshes expanded to over 4,000 $km^2$, covering a region of around 3,000 $km^2$ **(Partow et al., 2006)**. The water depth in the Central Marshes ranges from 2 to 2.5 meters deep during the flood season **(CRIMW, 2007)**. Although, **(Al-Ansari, 2021)** mentions that the water depth approaches three meters in certain places. The Central Marshes' flooding rate in each prefecture is presented in **Table 1** and cited from CRIMW.

**Fig. 1** shows the soil samples adopted from the selected stations. The sites chosen for this investigation are 15 stations spread within Al-Ghebaysh marsh within central marshes, as shown in **Fig. 2**. The size of the study area is very large, but the samples that were taken can be considered sufficient to represent the study area, as important areas were taken from the central marshes. The soil samples were prepared using Proctor test protocols in line with **(ASTM D698, 2007)**.

**Table 1**. The flooding of Central Marshes 1/5/2007, CRIMW, 2007.

| Prefecture name | Qualified area for submersion $km^2$ | Currently Submerged area $km^2$ | Currently Un-flooded area $km^2$ | Immersion rate % |
|---|---|---|---|---|
| Amara | 1230 | 810 | 420 | 66 |
| Basra | 155 | 155 | 0 | 100 |
| Nasiriyah | 1035 | 620 | 415 | 60 |
| Total | 2420 | 1610 | 810 | 67 |

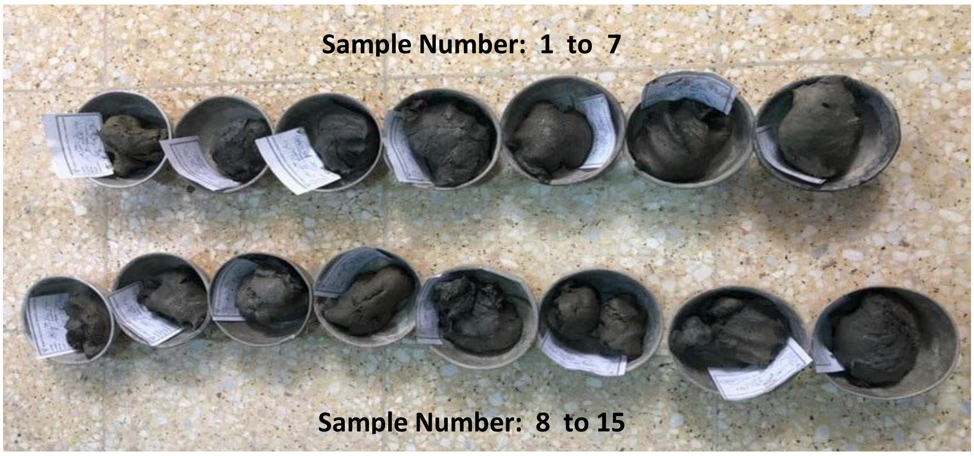


**Figure 1.** The Soil samples 1-15


**Figure 2.** Map of Central Marshes showing the locations of sampling sites.

## 3. RESULTS AND DISCUSSION

### 3.1 Mechanical Properties

Soil has been the most prevalent construction material used in engineering projects. The method used in this study is to collect soil from the study area and run many traditional tests on it to assess its geotechnical properties. Limits of Atterberg, conventional compaction consolidation, and soil shear strength are examples of these tests tested in a soil laboratory.

#### 3.1.1 Index Properties

A high Plasticity index (PI) indicates a soil's propensity to clay, a low PI indicates a soil's propensity for silt, and a PI of zero (non-plastic) indicates a soil's propensity for sands with little to no clay or silt. **Figs. 3 to 5** depict the Atterberg limits variety of collected samples in terms of Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI), respectively. **Table 1** displays the LL, PL, and PI test findings for the collected samples and compares them to the soil description limitations (**ASTM D2487, 2011**).

The liquid limit ranges between 33.9% and 52.1%, indicating a moderate to high water-holding capacity, as shown in **Fig. 3**. The wide range of liquid limit values indicates the soil's capacity to retain water, which can affect its engineering properties and suitability for various applications such as agriculture, construction, and land management.

**Table 1.** Atterberg Limits (LL, PL, and PI) results.

| Sample No. | LL | PL | PI | Soil description |
|---|---|---|---|---|
| 1 | 51.6 | 27.7 | 23.8 | High Plastic |
| 2 | 33.9 | 18.1 | 15.9 | Medium Plastic |
| 3 | 47 | 26.9 | 20.1 | High Plastic |
| 4 | 46.5 | 27.1 | 19.4 | Medium Plastic |
| 5 | 52.1 | 27.1 | 25 | High Plastic |
| 6 | 48.8 | 24.6 | 24.2 | High Plastic |
| 7 | 41.3 | 28.6 | 12.7 | Medium Plastic |
| 8 | 41.9 | 26.4 | 15.5 | Medium Plastic |
| 9 | 49.2 | 22 | 27.2 | High Plastic |
| 10 | 41.9 | 27.5 | 14.2 | Medium Plastic |
| 11 | 43.9 | 22.4 | 21.5 | High Plastic |
| 12 | 42.6 | 24.8 | 17.8 | Medium Plastic |
| 13 | 37.6 | 0 | 37.6 | Medium Plastic |
| 14 | 39.9 | 16.8 | 23.1 | High Plastic |
| 15 | 44.6 | 21.6 | 22.7 | High Plastic |

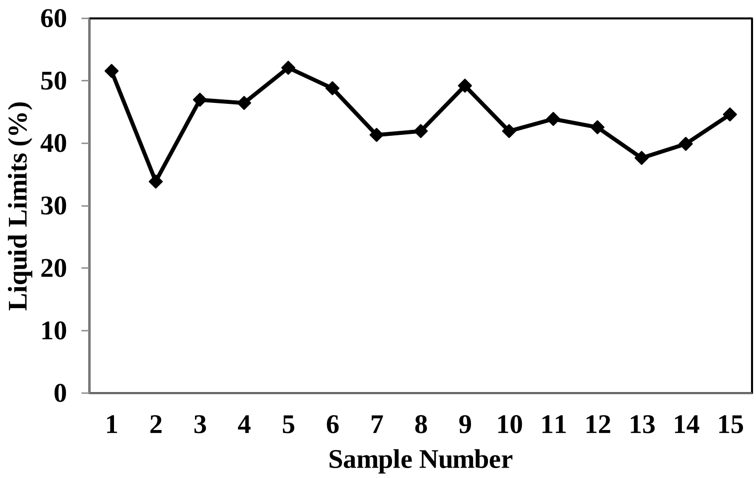


**Figure 3.** Variation of liquid limit (LL).

The variation in the plastic limit values in **Fig. 4** suggests differences in the soil's ability to undergo plastic deformation. This information can be useful for geotechnical engineers and construction professionals when designing foundations, embankments, and other regional structures.

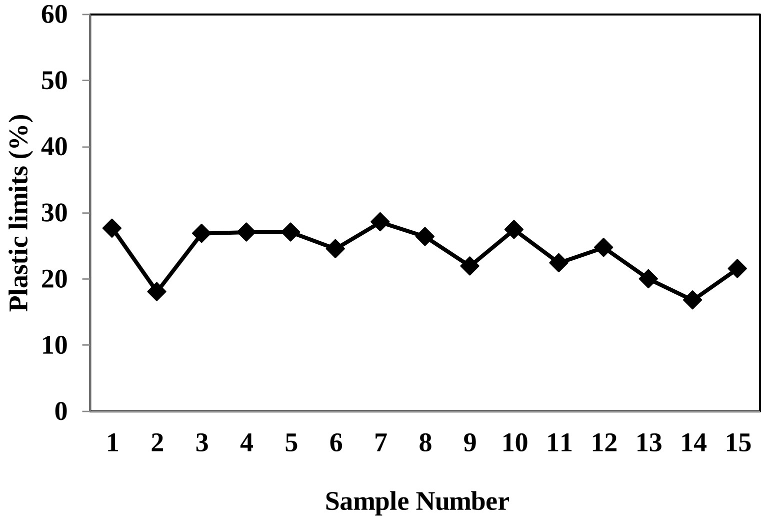


**Figure 4.** Variation of the plastic limits (PL).

The plastic index ranges between 12.7% and 37.6%, indicating the moisture content range in which the soil behaves as a plastic material, as shown in **Fig. 5**. These results suggest that Southern Iraq's Central Marshes bed soils have a significant water-retaining capacity and can exhibit plastic behavior over a range of moisture contents. These findings are essential for understanding the mechanical and physiochemical properties of the soils in the marshes, which are crucial for various engineering and environmental applications, such as land management, construction, and ecosystem preservation.

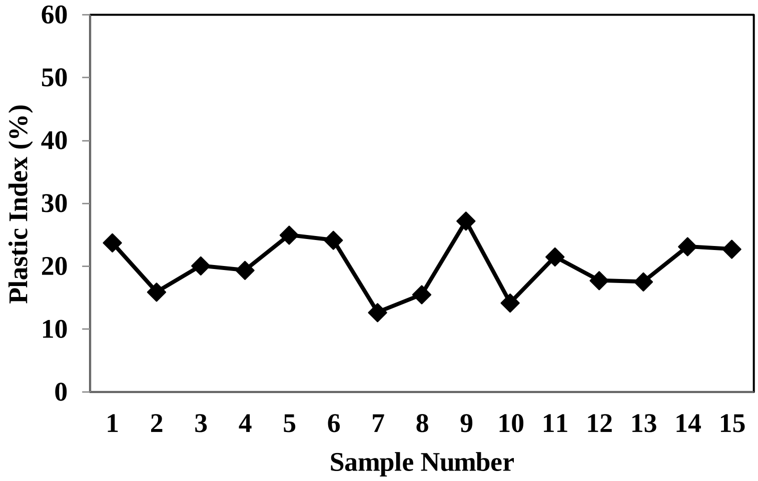


**Figure 5.** Variation of the plastic index (PI).

Generally speaking, the clay content is the sole factor that affects the plasticity index. It shows how thin the soil is and how easily it can change shape without losing volume. A high PI denotes an abundance of colloids or clay in the soil. Additionally, soil's plasticity refers to its capacity for deformation without cracking. It is a crucial fine-grained soil index characteristic, particularly for clayey soils. The plasticity index is maximum for clayey soil. From the outcomes, it can be concluded that the values of the plasticity range between medium plastic for PI less than 20 and high plastic for PI greater than 20 and has PL. When the PL is zero, that means purely silt and or sand. However, the soil of the central marshes is predominantly clay – silt and the more plastic the soil, the more expansive it will likely be. It is worth mentioning that the high plasticity soil has LL greater than 50 and vice versa for low plasticity fine-grained soil. The silt and clay type can be determined from the well-known A-chart and its equation of PI= 0.73(LL-30) that separates the silt (below A-line) and the clay (above A-line). The PI of silt soil in **Table 1** is below the PI calculated from the equation using the LL in **Table 1** and vice versa for the clay.

### 3.1.2 Strength Tests

The strength tests can be divided into:

**i.** *Unconfined Compressive Strength Tests*

When a soil sample is loaded quickly during an unconfined compression test, the pore pressures (water inside the soil) vary and do not have time to disperse. The test is strain-controlled **(Sujatha et al., 2020)**. Since the rate of building is highly rapid and the pore fluids do not have time to disperse, it indicates soils on construction sites. (**ASTM D2166, 2006)** Standard is a set of accepted test procedures.
Unconfined compressive tests are one of the methods used to determine the bearing capacity of the soil and were aimed at measuring the bearing capacity of the 15 collected soil samples. **Fig. 6** shows the unconfined compressive strength results for collecting soil samples in the Marshes area. The results proved that the unconfined compressive strength ranges between 7 kPa as a minimum value and 65 kPa as a maximum value. It also can be said that the average soil value is 47.125 kPa.

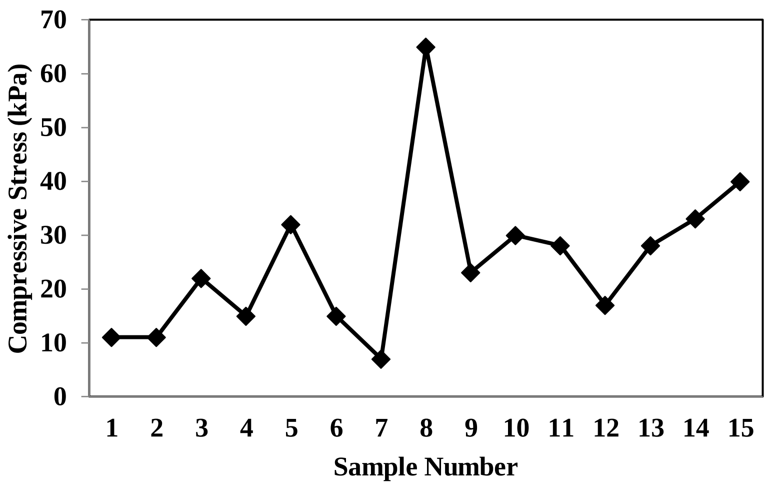


**Figure 6.** Results of unconfined compressive strength of collected samples.

*ii. Direct Shear Strength Tests*

A series of direct shear tests determined the shear strength characteristics of the dry and wet samples. The tests were conducted following the methodology suggested by (**ASTM D3080/D3080M, 2011**). The specimen measured (60×60×20) mm in size. For measuring vertical deformation, a calibrated proving ring with a (200) kg capacity and (0.002) mm precision dial gauge was employed, whereas a (0.001) mm gauge was used for measuring horizontal deformation. The strain was occurring at (0.3) mm/min. Three hours were spent soaking in the water (**Al-Zaidy et al.**, **2019**).

Tests were done on fifteen (15) samples from soil samples from the central marshes to forecast the shear strength parameters (cohesion C and friction angle $\phi$). The cohesion and friction angles tests are presented in **Figs. 7 and 8** show the results of direct shear testing performed on the studied soils. The results showed that the relationship of soil type with cohesion and friction angle is directly related, as dry soil and soaked soil differ regarding cohesion values. With an increase in cohesion value, the soil tends to be clay soil, while a decrease in its value represents the soil's tendency to be sandy.

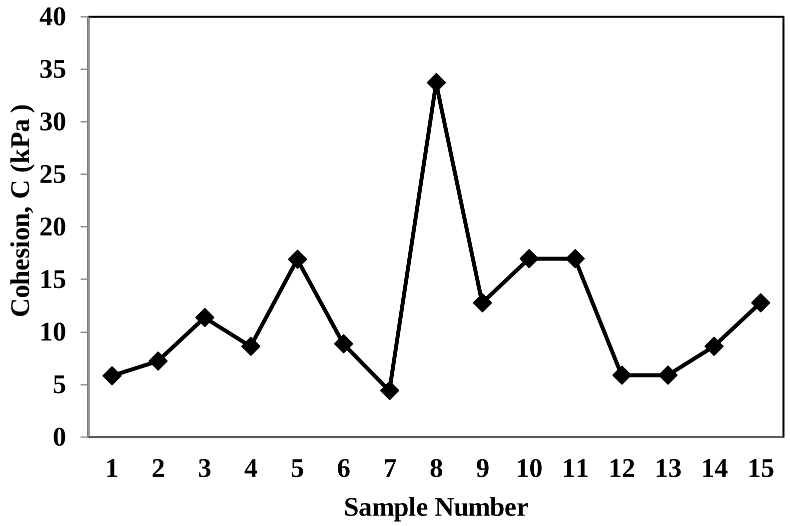


**Figure 7.** Results of cohesion of collected samples.

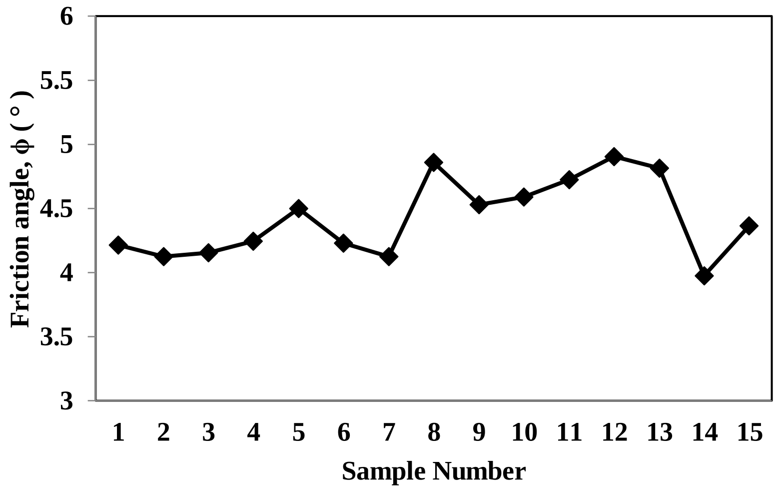


**Figure 8.** Results of friction angle of collected samples.

*iii. Consolidation Test*

The mechanical process through which soil progressively changes volume in response to a change in pressure is known as soil consolidation. The following equation, which calculates the volume change of a soil layer, can be used to express consolidation:

$$\delta_c = \frac{C_c}{1+e_0} H \log \left(\frac{\sigma_{zf}}{\sigma_{z0}}\right) \quad (1)$$

Where $\delta_c$ is the settlement due to consolidation, $C_c$ is the compression index, $e_0$ is the initial void ratio, $H$ is the height of the compressible soil, $\sigma_{zf}$ is the final vertical stress and $\sigma_{z0}$ is the initial vertical stress.
The results of consolidation tests conducted on the sampled soils are given in **Figs. 9 to 12**. It can be shown that the measured void ratio is, on average of, 0.95, which reflects the nature of the soil of very high compressibility and deformation, as shown in **Fig. 9**. **Fig. 10** shows that the soil is "over-consolidated" since its weight was removed **(Ahmed and Jahanger, 2008; Jahanger, 2011)**. Pre-consolidation stress ($\sigma'_p$) is the greatest stress to which it has been subjected. The maximum stress encountered divided by the present stress is called the "over-consolidation ratio" (OCR). When the soil has an OCR of 1, it is considered "typically consolidated" under the greatest stress. Before, the extra pore water pressure has subsided, but after a fresh load has been placed, the soil may be deemed "under-consolidated" or "unconsolidated." A phenomenon known as "intrinsic consolidation" occasionally occurs in soil layers created by natural deposition in rivers and oceans when the density is so low that it is hard to measure with an Oedometer. **Figs. 11 and 12** show that the compression and rebound indexes are 0.30 and 0.17, respectively. These indicate that the soil is very soft and has a high content of fine-grained soils such as silt and clay.

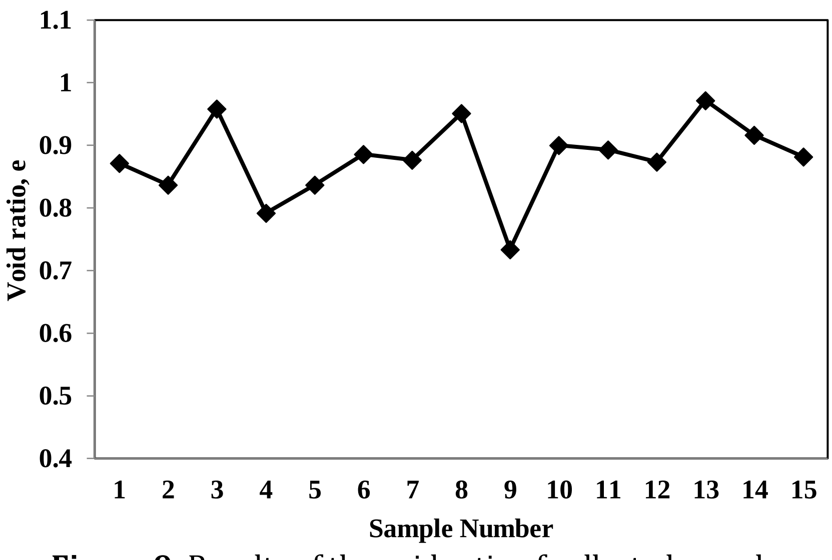

**Figure 9.** Results of the void ratio of collected samples.

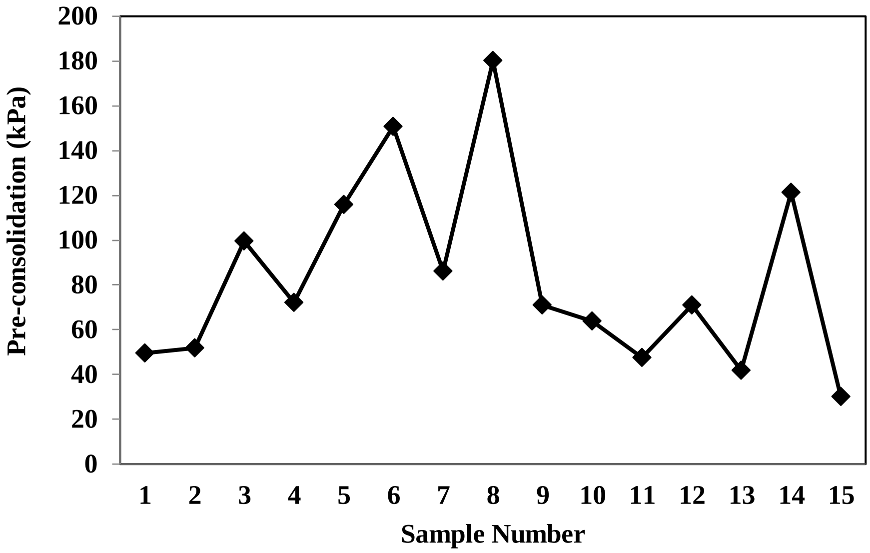


**Figure 10.** Results of pre-consolidation of collected samples.

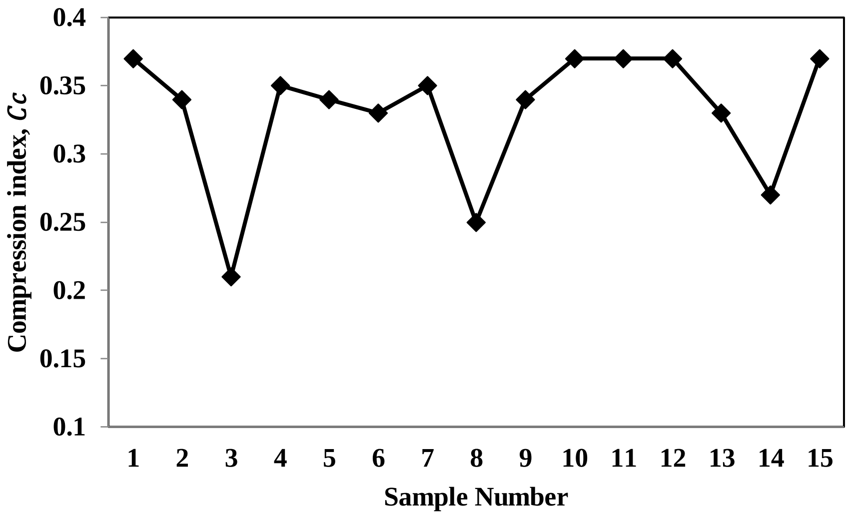


**Figure 11.** Results of compression index of collected samples.

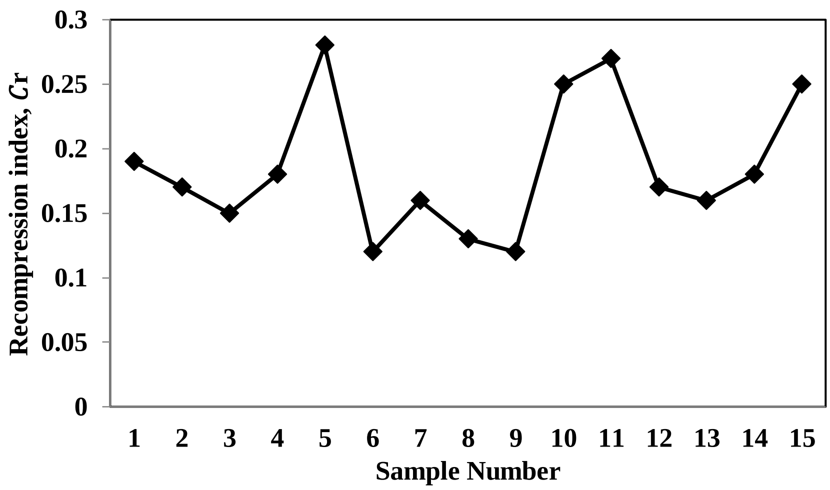

**Figure 12.** Results of recompression index of collected samples.

### 3.2 Physical Properties

The physical characteristics of the soil are of great importance in its agricultural uses, as it is important in the operations of cultivation, irrigation, drainage, management, maintenance of soil and water, and fertilization. These characteristics may include the following:

#### 3.2.1 Texture and Sieve Analysis

Soil texture means the relative distribution of aggregates of different sizes of mineral soil particles, which are represented by sand, silt, and clay. The size of these aggregates is less than (2 mm) in diameter, and through them, it can be learned about the roughness or softness of the soil. The results of sieve analysis of the selected samples, and according to USCS and the standard specification (**ASTM D 2487, 2011)**, the soil of Central marshes can be classified as clay-silty soil, which is the best suitable for crop agriculture. The results of sieve analysis of the selected samples, and according to **USCS and ASTM D 2487-11**, the soil can be classified and presented as tabulated in **Table 2**.

**Table 2.** Sieve analysis results.

| Sample No. | Sand (%) | Clay (%) | Soil description |
|---|---|---|---|
| 1 | 8.6 | 91.4 | CH |
| 2 | 22.8 | 77.2 | CL |
| 3 | 14.6 | 85.4 | CL |
| 4 | 20.7 | 79.3 | CL |
| 5 | 16.5 | 83.5 | CH |
| 6 | 4.8 | 95.2 | CL |
| 7 | 10.1 | 89.9 | ML |
| 8 | 7.3 | 92.7 | ML |
| 9 | 5.5 | 94.5 | CL |
| 10 | 9.4 | 90.6 | ML |
| 11 | 20.3 | 79.6 | CL |
| 12 | 7.4 | 92.6 | CL |
| 13 | 16 | 84 | ML |
| 14 | 11.3 | 88.7 | CL |
| 15 | 2.4 | 97.6 | CL |

#### 3.2.2 Water Content

The amount of water contained in the soil at a specific time and the need to study the moisture content of the soil lies in the great importance of soil water in plant life, as large quantities of water must be provided to meet the plants' needs for the evaporation/transpiration process. The amount of water contained in the soil of the selected samples ranged from 0.35 to 0.58%. These results indicate that the consistency of the soils is soft. The results of the selected samples can be presented in **Fig. 13**.

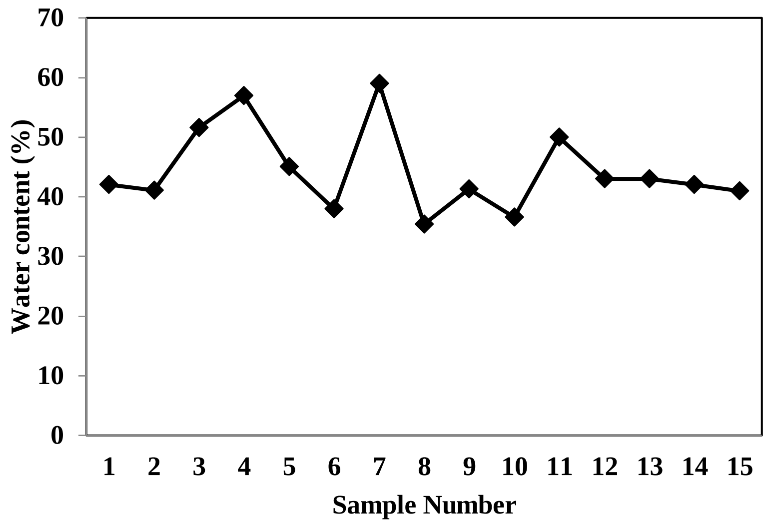


**Figure 13.** Results of water content analysis of collected samples.

3.2.3 Specific Gravity

The density of the filtered water $\rho_w$ is calculated using particular tables depending on the water's temperature that was collected in the previous stage (i.e., $\rho_w = 998.23$ kg/m$^3$ at T=20°C). The specific gravity of central marshes soils is usually between 2.65-2.68 due to the organic matter, as presented in **Fig. 14**.

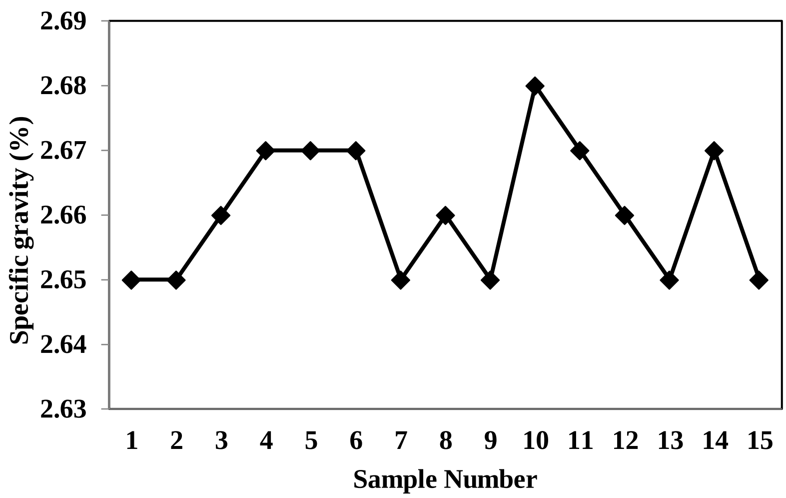


**Figure 14.** Results of specific gravity of collected samples.

3.2.4 Dry Density

After the cylinder is pulled out, the sample is ready and placed in an oven to dry for 24 hours at around 105°C to calculate its mass. The diameter and height measurements of the soil sample are used to calculate the volume. **Fig. 15** shows the findings for the dry density of the chosen samples.

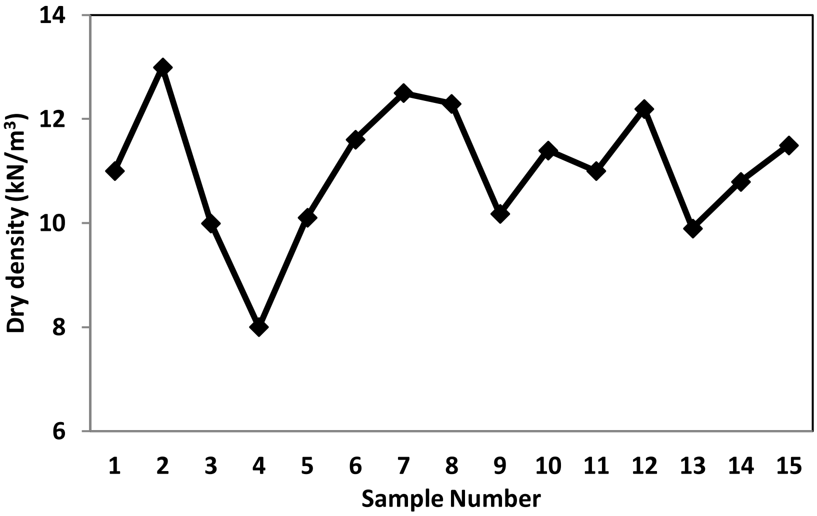


**Figure 15.** Results of dry density of collected samples.

3.2.4 Permeability

Various variables, including particle size, water impurities, void ratio, degree of saturation, adsorbed water, entrapped air, and organic material, influence the permeability of soils. It is measured as the amount of water ($m^3$) that can move through space ($m^2$) per unit time ($m^3/m^2$/day, or more simply m/day) and is generally denoted by the letter 'k.' The tests conducted on the samples found that the value of permeability ranges between (0.864-0.0864 m/day) and through this, it can be said that the soil of the central marshes is clay-silt.

### 3.3 Chemical Prosperities

The chemical properties of soils in the world differ from one site to another and from one place to another. This subsection will study the chemical properties by addressing the PH, Total Soluble Salts TSS, Total Sulphate Content $SO_3$, and organic materials OM. These examinations are sufficient to represent the study area for geotechnical purposes and are not related to science and environmental problems.

- pH

The degree of soil interaction (pH) refers to the effective concentration of hydrogen ions (H) in the soil solution, and it is expressed by the (pH) scale, whose value ranges between (1-14). According to **(BS 1377, 1975)**, **Table 3** classifies soil according to its degree of salinity. pH values for the studied soils ranged from 7.45 to 8.65.

**Table 3.** Soil classification according to its degree of salinity

| **Soil class** | **Low saline** | **Medium saline** | **High saline** | **Very high saline** |
|---|---|---|---|---|
| dm/m | 0.4 | 5-8 | 8-14 | >14 |

The pH results of the selected samples can be presented in **Fig. 16**. From this, it can be concluded that the salinity of the marsh soils, depending on the pH value, ranges between (Medium saline to High saline).

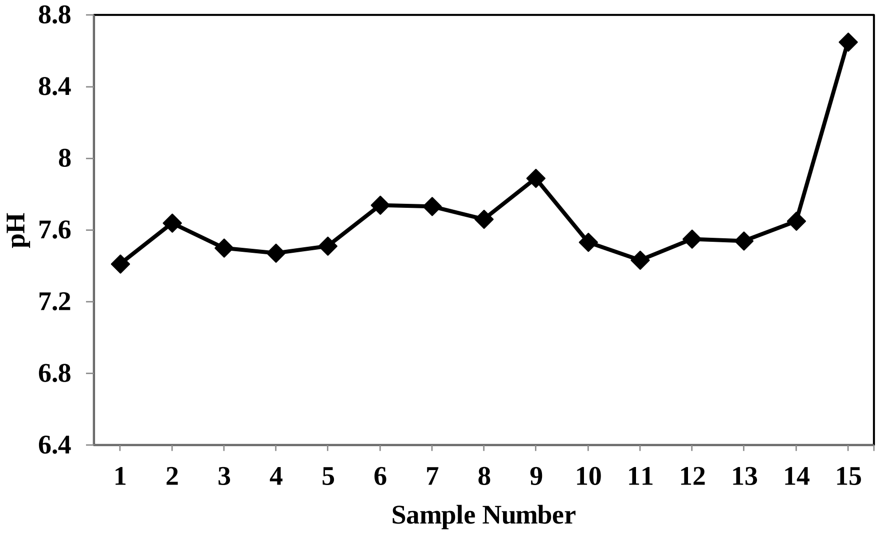


**Figure 16.** Results of pH of collected samples.

- Total Soluble Salts TSS

Total soluble salts are the total salt content of the soil extract, measured in parts per million (ppm). The salts are composed of sodium and chloride, the two main components of table salt, as well as calcium, magnesium, potassium, nitrate, sulfate, and carbonates. The soluble salts calcium, magnesium, sodium, chloride, sulfate, and bicarbonate are frequently found in soils. Potassium, ammonium, nitrate, and carbonate are also in lower amounts. Total soluble salt results ranged from 0.75% to 1.5%. According to **Earth manual E8 Standard Specification**, the TSS results of the selected samples can be presented in **Fig. 17**.

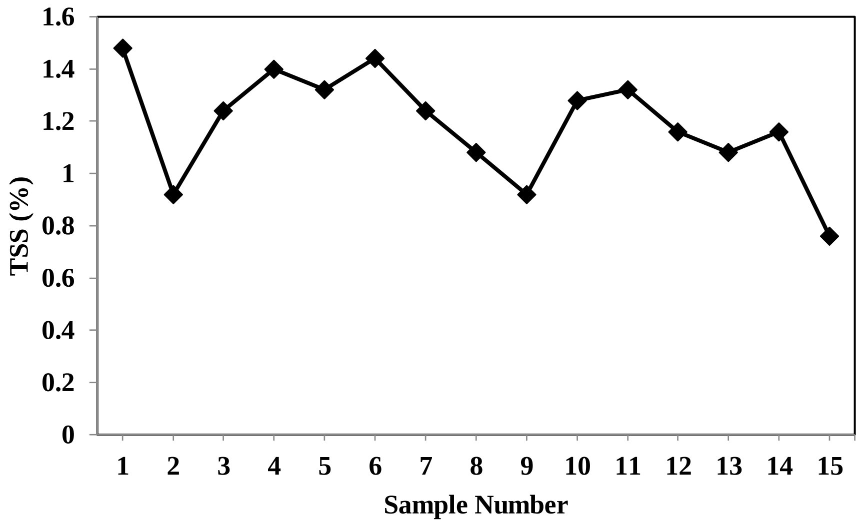


**Figure 17.** Results of TSS of collected samples.

- Organic Materials OM.

Any dead or alive animal or plant material is considered organic matter. Animals and plants remain in different stages of decomposition; live plant roots, microbes, and excretions are all included. The OM results of the selected samples appeared with values ranging from 4.5% to 9.5%. According to the **(BS 1377, 1975) Standard**, the OM results of the selected samples can be presented in **Fig. 18**.

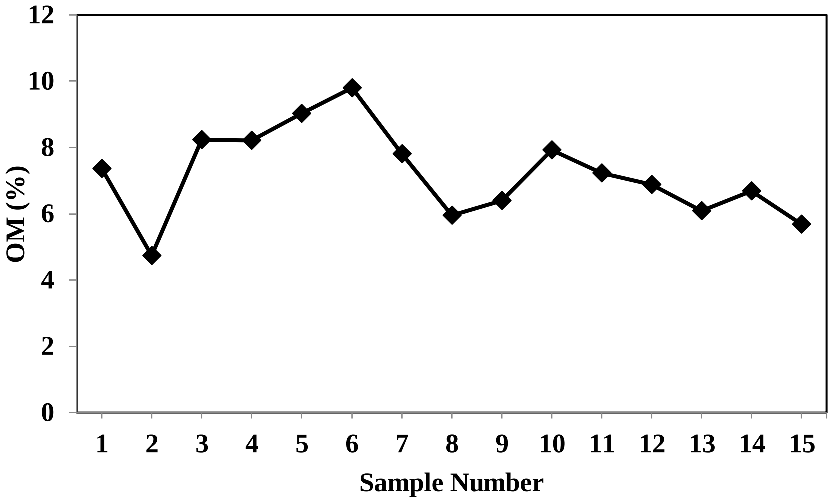


**Figure 18.** Results of OM. of collected samples.

- Total Sulphate Content ($SO_3$)

The quantified concentration of the polyatomic anion of Sulphur and oxygen atoms present in the solution is referred to as "sulfate ion content." A more acidic solution environment created by a greater sulfate ion concentration increases corrosion rates. According to **(BS 1377, 1975)**, the $SO_3$ results of the selected samples can be presented in **Fig. 19**.

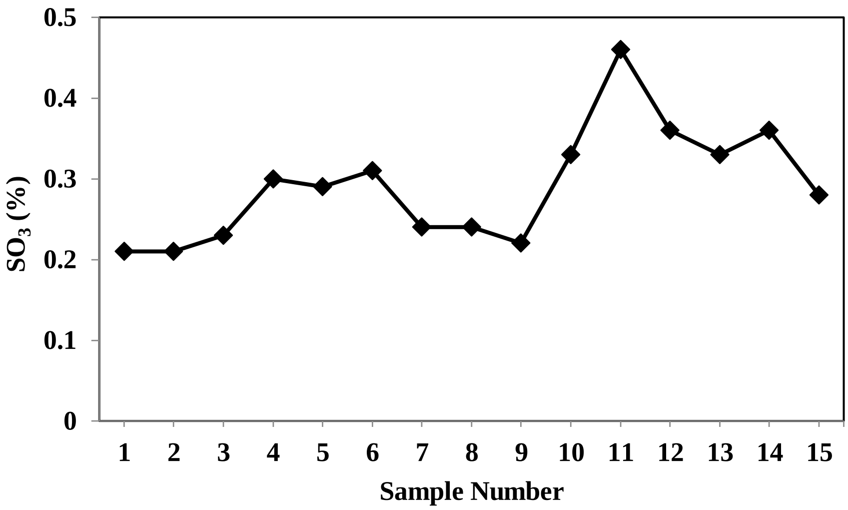


**Figure 19.** Results of $SO_3$ of collected samples.

## 4. CONCLUSIONS

This study aims to evaluate the soil quality in terms of mechanical, physical, and chemical of certain sites in southern Iraqi Central Al-Chibayish Marshes. Then, it will investigate their types and suitability for enhancing the agricultural reality of most field crops. Soil samples were collected from 15 sites for a 10-100 cm depth and transferred to the soil laboratory. Below are the most important conclusions obtained:

1. The amount of water contained in the soil of the selected samples ranged from 0.35 to 0.58%.
2. Soils typically have a specific gravity of 2.65 to 2.68.
3. The findings of the selected samples' dry density (2.65-2.68 kN/m$^3$).
4. The tests conducted on the samples found that the value of permeability ranges between (0.00001-0.000001).
5. The quantified concentration of the polyatomic anion of sulfur and oxygen atoms in the solution was called "sulfate ion content."
6. pH values for the studied soils ranged from 7.45 to 8.65.
7. Total soluble salt results ranged from 0.75 to 1.5%.
8. The OM results of the selected samples appeared with values ranging from 4.5 to 9.5%.
9. The results of sieve analysis of the selected samples, and according to **USCS and the standard specification ASTM D 2487-11**, the soil of Central Marshes can be classified as clay-silty soil, which is the best suitable for agriculture of crops.
10. Using these sites for agriculture can be recommended to raise the agriculture field in southern Iraq.

## REFERENCES


Abbas, N., Wasimi, S., Al-Ansari, N., and Sultana, N., 2018. Water resources problems of Iraq: Climate change adaptation and mitigation. *Journal of Environmental Hydrology*, 26, P. 6.

Ahmed, A.A., and Jahanger, Z.K., 2008. Skin Friction Between Undisturbed Over Consolidated SILTY Clay Soils and Concrete. *Journal of Engineering*, 14(4), pp. 3068-3076.

Al-Abbawy, D.A.H., and Al-Mayah, A.A., 2010. Ecological survey of aquatic macrophytes in restored marshes of southern Iraq during 2006 and 2007. *Marsh Bulletin*, 5(2), pp. 177-196.

Al-Ansari, N., 2021, Water Resources of Iraq. *Journal of Earth Sciences and Geotechnical Engineering*, 11(2), pp. 15-34. Doi:10.47260/jesge/1122

Albarakat, R., Lakshmi, V., and Tucker, C.J., 2018. Using satellite remote sensing to study the impact of climate and anthropogenic changes in the Mesopotamian marshlands. Iraq. *Remote Sensing,* 10(10), 1524. Doi:10.3390/rs10101524

Al-Jasimee, A.S., Abed, S.A., Salim, M.A., and Harjan, Q.J., 2020. studying the diversity of freshwater ecosystems in Iraq. do we need different approaches. *Journal of Physics: Conference Series, 1664(1), P. 012141). IOP Publishing.* Doi:10.1088/1742-6596/1664/1/012141

Al-Mudaffar Fawzi, N., Goodwin, K.P., Mahdi, B.A., and Stevens, M.L., 2016. Effects of Mesopotamian Marsh (Iraq) desiccation on the cultural knowledge and livelihood of Marsh Arab women. *Ecosystem Health and Sustainability,* 2(3), e01207. Doi:10.1002/ehs2.1207

Al-Mukhtar, M., and Al-Yaseen, F., 2019. Modeling water quality parameters using data-driven models, a case study Abu-Ziriq marsh in south of Iraq. *Hydrology,* 6(1), 24. Doi:10.3390/hydrology6010024

Al-Saad, H.T., and Al-Timari, A.A., 1993. Seasonal variations of dissolved normal alkanes in the water marshes of Iraq. *Marine pollution bulletin*, 26(4), pp. 207-212. Doi:10.1016/0025-326X(93)90623-R

Al-Sudani, H.I.Z., 2017. Groundwater Investigation in Iraqi Marshland Area. Diyala Journal For Pure Science, 13(3-part 3).

Al-Suhili, R.H., and Ghafour, Z.J., 2013. Genetic algorithm optimization model for central marches restoration flows with different water quality scenarios. *Journal of Engineering*, 19(3), pp. 312-330. Doi: 10.31026/j.eng.2013.03.03.

Alwan, I.A., and Aziz, N.A., 2021. An accuracy analysis comparison of supervised classification methods for mapping land cover using sentinel 2 images in the Al-Hawizeh marsh area, southern Iraq. *Geomatics and Environmental Engineering,* 15(1). Doi:10.7494/geom.2021.15.1.5 5

Alwan, I.A., and Aziz, N.A., 2022. *Monitoring of surface ecological change using remote sensing technique over Al-Hawizeh Marsh, Southern Iraq, Remote Sensing Applications: Society and Environment*, P. 100784. Doi:10.1016/j.rsase.2022.100784

Al-Zaidy, K.J., Parisi, G., Abed, S.A., and Salim, M.A., 2019. Classification of the key functional diversity of the marshes of southern Iraq marshes. *Journal of Physics: Conference Series,* 1294(7*),* P. 072021. IOP Publishing. Doi:10.1088/1742-6596/1294/7/072021

ASTM, D. 2020. Standard test method for direct shear test of soils under consolidated drained conditions. D3080/D3080M, 3(9). https://www.astm.org/standards/d3080.

ASTM, D., 2016. 2166. Standard test method for unconfined compressive strength of cohesive soil. West Conshoshocken, PA, United States. https://www.astm.org/d2166-06.html.

ASTM, D., 2007. 698; Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft$^3$ (600 kN-m/m$^3$ )). ASTM International: West Conshohocken, PA, USA, (19428-2959). https://www.astm.org/d0698-12r21.html

ASTM., 2004. E8. Standard test method for tension testing of metallic materials. West Conshohocken (USA): ASTM. https://www.galvanizeit.com/uploads/ASTM-E-8-yr-13.pdf.

ASTM., 2006. D698, Standard test methods for laboratory compaction characteristics of soil using standard effort. ASTM International, West Conshohocken, PA. https://www.resolutionmineeis.us/sites/default/files/references/astm-D698.pdf.

BS. 1377. 1975. Methods of testing soils for civil engineering. http://www.malaysiaconstructionservices.com/pepc-exam-civil-engineering-paper/bs1377methodsoftestforsoilsforcivilengineeringpurposes.

CRIMW, 2007. Center for Restoration of the Iraqi Marshes and Wetlands Restoration of Al-Hammar Marsh study: evaluation of Al-Malha project. Ministry of Water Resources.

Daham, A., Han, D., Rico-Ramirez, M., and Marsh, A., 2018. Analysis of NVDI variability in response to precipitation and air temperature in different regions of Iraq, using MODIS vegetation indices. *Environmental Earth Sciences,* 77(10), pp. 1-24*.* Doi:10.1007/s12665-018-7560-x.

Hammer, E., 2022. Multi-centric, Marsh-based Urbanism at the early Mesopotamian city of Lagash (Tell al-Hiba, Iraq). *Journal of Anthropological Archaeology,* 68, P. 101458. Doi:10.1016/j.jaa.2022.101458

Hasab, H.A., Jawad, H.A., Dibs, H., Hussain, H.M., and Al-Ansari, N., 2020. Evaluation of water quality parameters in marshes zone southern of Iraq based on remote sensing and GIS techniques. *Water, Air, and Soil Pollution,* 231(4), pp. 1-11. doi:10.1007/s11270-020-04531-z

Hashim, B.M., Sultan, M.A., Attyia, M.N., Al Maliki, A.A., and Al-Ansari, N., 2019. Change detection and impact of climate changes to Iraqi southern marshes using Landsat 2 Mss, Landsat 8 Oli and sentinel 2 Msi data and Gis applications. *Applied Sciences*, 9(10). doi:10.3390/app9102016

Hason, M.M., Abbood, I.S., and Aldeen Odaa, S., 2020. Land cover reflectance of Iraqi marshlands based on visible spectral multiband of satellite imagery. *Results in Engineering, 8, 100167.* doi:10.1016/j.rineng.2020.100167

Jahanger, Zuhair K., 2011. Relation between standard penetration test and skin resistance of driven concrete pile in over consolidated clay soil. Journal of Engineering, 17(5), pp. 65-78.

Jasim, I.A., Al-Maliki, L.A., and Al-Mamoori, S.K., 2022. Water corridors management: a case study from Iraq. *International Journal of River Basin Management*, pp. 1-11. Doi:10.1080/15715124.2022.2079662

Khidher, S. A., 2019. *Geographical changes in the marshes of Iraq*. *Journal of the College of Education for Women,* 30(1), pp. 10-31.

Marsh, A., Fleitmann, D., Al-Manmi, D.A.M., Altaweel, M., Wengrow, D., and Carter, R., 2018. Mid-to late-Holocene archaeology, environment and climate in the northeast Kurdistan region of Iraq. *The Holocene,* 28(6), 955-967. Doi:10.1177/0959683617752843

Partow, H., and Jaquet, J., 2006. Iraqi Marshlands Observation System—UNEP Technical Report. *UNEP: Nairobi, Kenya*, p.74.

Salim, M.A., Abed, S.A., Jabbar, M.T., Harbi, Z.S., Yassir, W.S., Al-Saffah, S.M., and Alabd-Alrahman, H.A., 2020. Diversity of avian fauna of Al-dalmaj wetlands and the surrounding terrestrial areas, Iraq. *Journal of Physics: Conference Series, 1664(1), P. 012105. IOP Publishing.* Doi:10.1088/1742-6596/1664/1/012105

Salim, S.M., 2021. *Marsh dwellers of the Euphrates delta.* 1st Ed., Routledge. London. Doi;10.4324/9781003135272.

Soils, B.S., ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM AASHTO M 145 Soil Classification Groups A-1, (pp. 311000-3). https://lauwtjunnji.weebly.com/uploads/1/0/1/7/10171621/astm_d-2487_classification_of_soils_for_engineering_purposes_unified_soil_classification_system.pdf.

Sujatha, S.J., Jahanger, Z.K., Barbhuiya, S., and Antony, S.J., 2020. Fabrics-shear strength links of silicon-based granular assemblies. *Journal of Mechanics*, 36(3), pp.323-330.