Assessment of Soil and Water Properties in the Central Marshes Southern Iraq

Riyam R. Kareem[1, a *] and Zuhair K. Jahanger[1,b]

[1]Department of Water Resources Engineering, University of Baghdad, Baghdad, Iraq

[a]riyam.karam2010m@coeng.uobaghdad.edu.iq and [b]zk_jahanger@coeng.uobaghdad.edu.iq

*Corresponding author

Abstract. The Central Marshes are one of southern Iraq's most important wetlands and ecosystems. A study on evaluating soil quality and water quality in terms of chemical properties at certain sites in the southern Iraqi Central Marshes has been conducted to investigate their types and suitability for enhancing the agricultural reality of most field crops. Soil and water samples were collected from 15 sites and transferred to the laboratory. In the lab, the following parameters were determined: electrical conductivity (EC), total dissolved salts (TDS), organic materials (OM), pH, gypsum, and total sulfate content (SO_3). The tests conducted on the samples indicated that it could be said that the soil of the Central Marshes is dark blackish-gray silty clay or clayey silt soil and revealed that most of the southern marshlands are suitable for planting different crops. Analysis of the results may have a role in designing and planning upcoming projects such as construction and agriculture, which would have to enlighten the decision maker.

Keywords: Soil quality, water quality, central marshes, southern Iraq, geotechnical properties.

1. INTRODUCTION

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 [1]. In the spring, when the Tigris and Euphrates rivers flood, the marshes are filled with water; during the summer, surplus water flows into the Arabian Gulf [2,3,4]. The marshes, which are located in Iraq between latitudes 35° 30' and 32° 45' N and between longitudes 13° 46' and 48° 00' E [5], have an area of 35,000 km^2, of which around 9000 km^2 represents a permanent marsh filled and covered with water over the year. Other 9000 km^2 are non-permanent marshes filled with water during rain, while the rest are shallow areas and covered with Phragmites australis and Typha domingensis [6,7]. The Central Marshes are characterized as plain lands, some of which are fertile and suitable for planting economic crops, while others contain high levels of salts. Most of the land in these marshes is covered with water throughout the year, producing large quantities of rice and corn. Phragmites australis and Typha domingensis grow heavily in non-planting areas. The Central Marshes, spanning around 3000 km2 during the flood season, are situated between Nasiriyah, Maimona, Qalat Saleh, and Al-Qurna. The region typically shrinks to 600 km^2 in the dry season. The Tigris River tributaries in the Ammara governorate serve as the primary water supplies for the Central Marshes. These tributaries include Al-Areed, Al-Bittera, and Al-Majar Al-Kabeer rivers [8,9].

Soil and water chemical properties vary from one site to another and from one place to another in the world. Hence, the Marshes' new plan is to invest in the Marshes area. Therefore, the analysis of the results may have a role in enlightening the decision-maker in the design and planning of upcoming agriculture projects. Knowing and assessing marsh soil quality is crucial in studying the ecosystem characteristics related to hydrology, climate change, and plants [10,11]. Water quality is a crucial factor in controlling the health and disease of both humans and animals. Natural processes such as weathering, precipitation, sediment transportation, and anthropogenic activities such as municipal and industrial wastewater effluents, urban development, and farming impact the quality of water in an area [12]. Anthropogenic waste is a persistent source of contamination, and water quality fluctuations are commonly associated with seasonal changes that are heavily influenced by climate patterns [13]. Nonetheless, thorough investigations into the anthropogenic contamination of ecosystems are continuously conducted in regions that receive such pollutants [14]. In recent decades, there has been an increasing demand for the frequent monitoring of different water quality parameters to observe the standards of various rivers and water resources [15]. As a result, water quality remains a topic of ongoing concern.

Many studies have dealt with the morphological and taxonomic characteristics of the marsh soils in Iraq, but studies of the chemical properties of the water and soil of this environment are still limited. As marshlands are economically important, this study aims to investigate some chemical properties of their soils to identify their suitability for agriculture and enhance the agriculture reality of most field crops.

2. METHODS AND APPARATUS

In the winter season of 30 January 2023, a comprehensive investigation was conducted in the Central Marshes, specifically within Al-Ghebaysh marsh. A total of fifteen stations were carefully selected for examination, as depicted in Figure 1. Soil samples were collected using special tools from the selected stations and placed in plastic bags at the selected depths. The samples were then transferred to the laboratory in a cool box and kept in the fridge before analysis. The soil was oven-dried at (105-110) °C for 24 hours. Proctor test protocols in line with ASTM Standards (D-698) were used to prepare the soil samples [16]. Water samples were also collected from 15 different locations and were put in glass jugs.

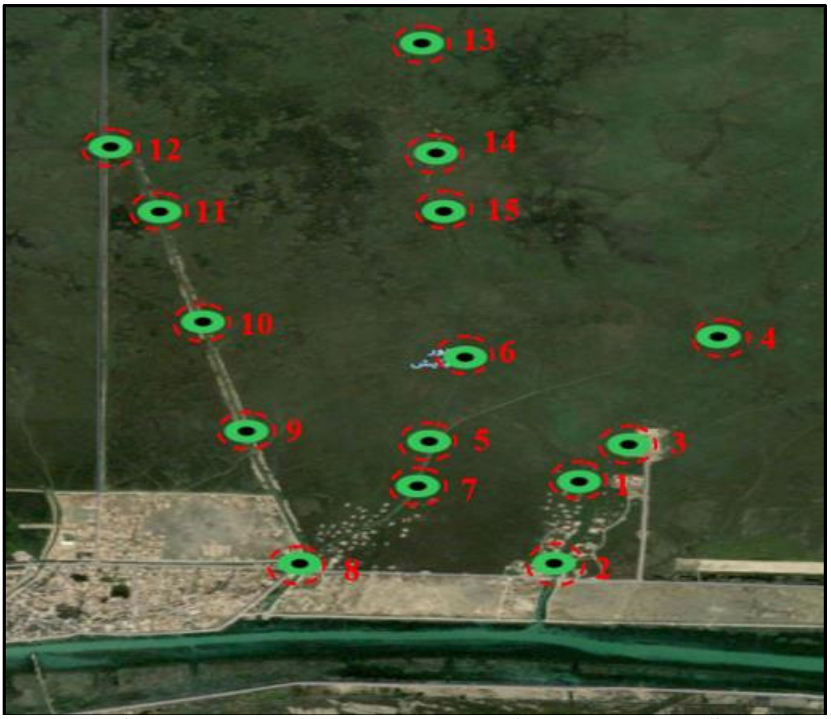


Figure 1: Map of central marshes showing the locations of sampling sites by offline maps.

3. LABORATORY ANALYSIS

In the lab, the soil chemical properties, such as pH, total dissolved salts (TDS), organic materials (OM), Chloride (Cl^-), Gypsum, and total sulfate content SO_3, were determined. As for the chemical tests of the water, the electrical conductivity (EC) was also examined in addition to the above-mentioned tests.

4. RESULTS AND DISCUSSION

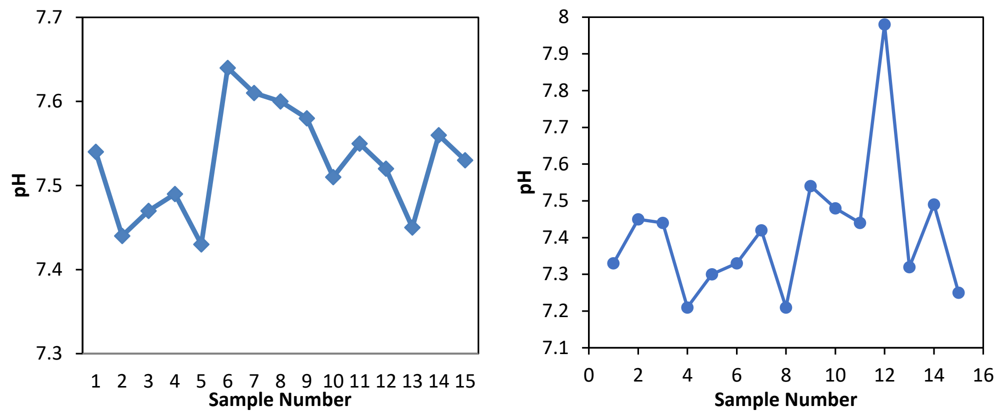
In this subsection, the soil and soil chemical properties will be studied by addressing the pH, TDS, OM, Gypsum, SO_3, and Cl^-, as the chemical properties of soil and water in the world differ from one site to another and from one place to another. Additionally, EC was measured for the 15 collected water samples.

4.1. pH Value

The effective concentration of hydrogen ions (H) in the solution is referred to as the degree of pH, which is expressed by the (pH) scale, with a value range between (1-14). Soil is classified according to its degree of salinity in Table 1, as reported by [17]. The pH results of the selected samples can be found in Figure 2a, which indicates that the salinity of marsh soils is medium saline based on the pH value. Additionally, the water was found to have a value not exceeding 8, as shown in Figure 2b, and is also classified as medium salinity based on Table 1. The difference in pH values between soil and water samples may be attributed to soil's buffering capacity, which can resist changes in pH caused by acidic or basic substances. Soil contains minerals and organic matter that can neutralize acidic or basic substances, while water lacks such buffering capacity and can be more susceptible to changes in pH value. Additionally, the pH of the soil can be influenced by factors such as vegetation, soil type, and fertilizers. In contrast, the pH of water can be influenced by factors such as dissolved minerals and pollutants. Therefore, the difference in pH values between soil and water samples may indicate the different conditions and processes occurring in these two environments.

Table 1: Soil classification according to its degree of salinity according to [3].

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

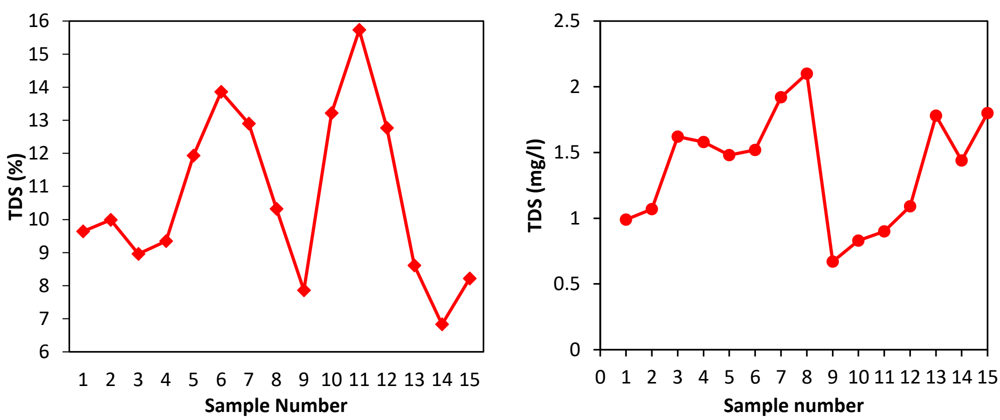


(a) the pH of soil samples. (b) the pH of water samples.

Figure 2: pH value results of collected samples.

4.2. Total Dissolved Salts TDS

The total salt content of the extract, measured in parts per million (ppm), is known as total dissolved salts. The salts are composed of sodium (Na^+) and chloride (Cl^-), the two main components of table salt, as well as calcium (Ca^{+2}), magnesium (Mg^{+2}), potassium (K^+), nitrate (NO_3^-), sulfate (SO_4^{-2}), and carbonates (CO_3^{-2}). Soluble salts such as calcium (Ca^{+2}), magnesium (Mg^{+2}), sodium (Na^+), chloride (Cl^-), sulfate ($SO4^{-2}$), and bicarbonate (HCO_3^{-1}) are frequently found in soil. Potassium (K^+), ammonium (NH_4^+), nitrate (NO_3^-), and carbonate (CO_3^{-2}) are also present, but in lower amounts. The TDS results of the soil and water samples can be presented in Figures 3a and 3b, respectively, according to [18]. The most important indication to assess the suitability of water is the sodium adsorption ratio, which shows that the soil is suitable for agriculture. Still, the water is not suitable for most types of plants.



(a) TDS of soil samples. (b) TDS of water samples.

Figure 3: TDS results of collected samples.

4.3. Organic Materials OM

Organic matter is considered any dead or alive animal or plant material. It includes animals and plants that remain in different stages of decomposition, live plant roots, microbes, and excretions. According to [17], the results of OM. for the selected soil and water samples can be presented in Figures 4a and 4b, respectively.

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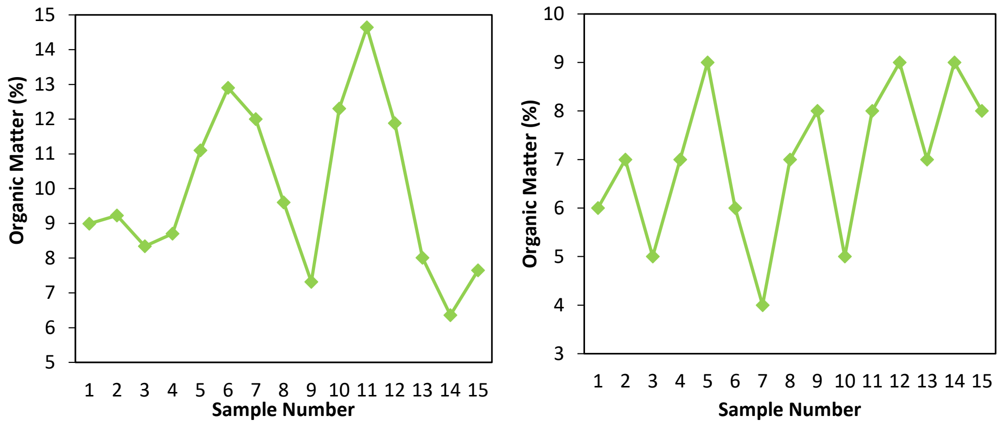


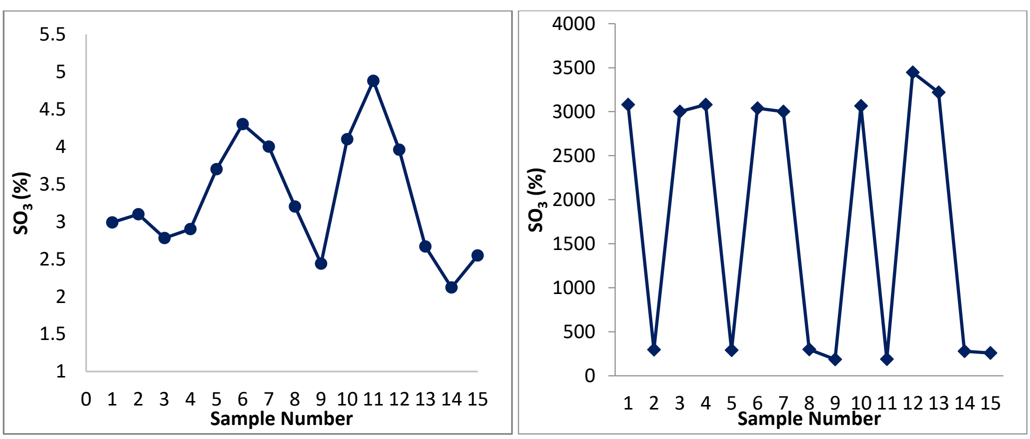
(e) OM of soil samples.

(f) OM of water samples.

Figure 4: Organic matter results of collected samples.

4.4. Total Sulphate Content SO_3

The concentration of sulfate ions in a solution, which measures the polyatomic anion of sulfur and oxygen atoms present, has significant implications for corrosion rates. An acidic solution environment created by an elevated sulfate ion concentration can increase corrosion rates. The SO_3 results obtained from the selected soil and water samples have been presented in Figures 5a and 5b, respectively, following reference [17].



(a) So_3 of soil samples.

(b) So_3 of water samples.

Figure 5. SO_3 results of collected samples.

4.5. Gypsum Content

Gypsum, a soft sulfate mineral composed of calcium sulfate dihydrate with the chemical formula $CaSO_4 \cdot 2H_2O$, is extensively mined and has a wide range of uses. It serves as a fertilizer and is the primary component of various forms of plaster, blackboard or sidewalk chalk, and drywall. The application of gypsum to soil enhances water absorption and reduces erosion, as well as curbing the movement of phosphorus from soils to lakes and streams and improving the quality of different fruits and vegetables, among other benefits. In addition, gypsum increases the water-use efficiency of crops, which is particularly critical in drought-stricken areas and times [19]. Enhanced hydraulic conductivity, improved water storage, and increased water infiltration rates of soil treated with gypsum facilitate deeper rooting and superior water-use efficiency [20-24]. Gypsum-treated soils contain 25 to 100 percent more available water compared to untreated soils. The gypsum content of the chosen soil and water samples can be depicted in Figures 6a and 6b, respectively.

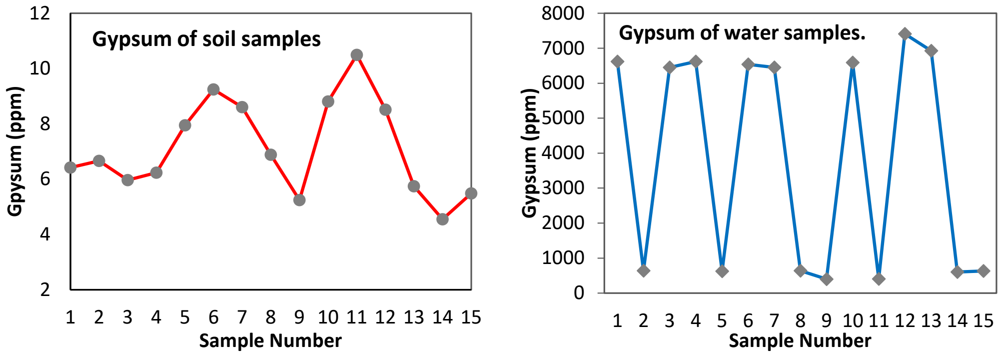


Figure 6: Gypsum results of collected samples.

4.6. Chloride Content

The harmful effects of chloride (Cl^-) on agriculture are attributed to its toxic effects on saline soils and its antagonistic interaction with nitrate (NO_3^-), which can impair NO_3^- nutrition. It has been widely accepted that Cl^- can antagonize the uptake and accumulation of NO_3^- in higher plants, leading to a reduction in crop yield. The selected soil and water samples' gypsum content can be presented in Figures 7a and 7b, respectively.

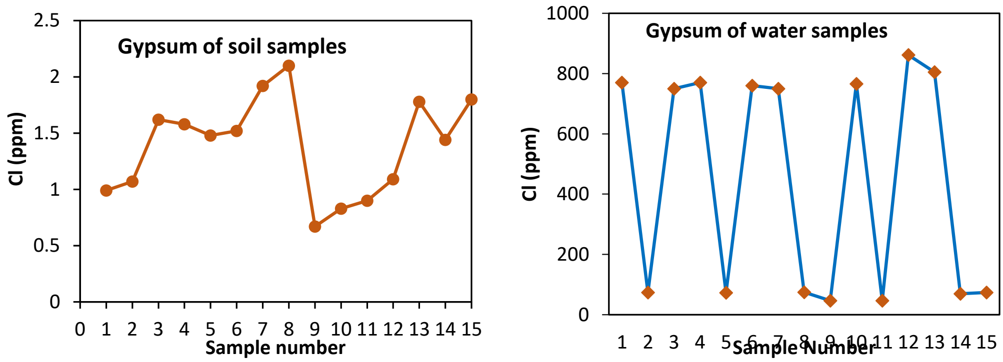


Figure 7: Chloride results of collected samples.

4.7 Electrical Conductivity (EC)

Water's ability to conduct electrical current is measured by conductivity, which increases as salinity, dissolved salts, and other inorganic chemicals increase. Pure water typically has a conductivity range of 0.5 to 3 µs/cm, while in Iraq, lake and river water generally ranges from 100 to 2500 µs/cm [25-26]. Figure 8 presents the gypsum content of the selected soil and water samples.

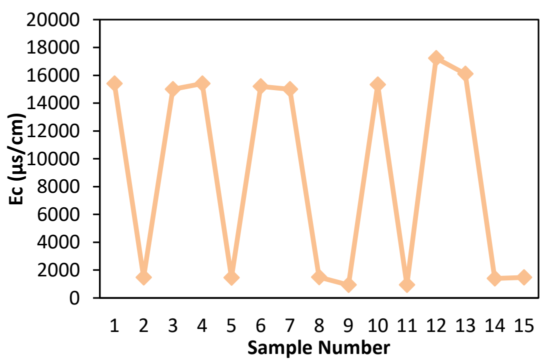


Figure 8: EC results of collected samples.

5. CONCLUSIONS

The study's results reveal important information about the soil and water characteristics of the Central Marshes in southern Iraq. The pH values of both water and soil samples were within the range of neutrality, which is generally considered favorable for most crops. The range of total dissolved salts and electrical conductivity in the water samples was quite wide, indicating that the water quality in the marshes varied significantly. The organic material content of both soil and water samples was relatively high, suggesting that the marshes have good potential for agriculture.

The wide range of gypsum and chloride content in the water and soil samples also highlights the variability in the water quality of the marshes. These differences in concentrations could be attributed to the varying water supply sources, including rainfall, surface runoff, and groundwater. Additionally, natural factors such as the geological characteristics of the region and the soil composition may also impact the concentrations of these parameters.

The study did not specifically identify the types of crops cultivated in the waters of the marshes. However, given the favorable pH and organic material content of the soil, it is likely that a wide variety of crops could be grown in this region, including rice, wheat, and barley. Climate change is a major global concern and can significantly impact water quality. Unfortunately, the study did not investigate how the marsh water quality has changed due to climatic changes. Further research is necessary to determine climate change's impact on the marshes' water quality, particularly in light of the increasing frequency of extreme weather events and rising temperatures.

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