



Research article

Spatial Variability of Soil physicochemical properties in Western Basra as a Baseline Dataset for Assessing Potential Environmental Impacts of oil Facilities

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ABSTRACT

This research aims to study the spatial distribution of the physical and chemical properties of soils in the southern and northern sandy areas of Basra Governorate. The objective is to evaluate the impact of environmental factors and human activities on soil characteristics and sustainability. Samples were collected from six selected sites within the study area in Basra Governorate and analyzed to determine physical and chemical properties, such as soil texture, bulk density, particle density, organic matter, calcium carbonate, calcium sulfate, pH, and EC. The results revealed distinct variations in the physical and chemical soil properties across the study sites, attributable to differences in sedimentary sources, process patterns, and environmental changes in the region. This research helps elucidate the relationship between soil properties and environmental conditions in the area, and contributes to guiding sustainable soil management policies for the region.

1. Introduction

Sandy soils in Iraq cover a vast area extending from the northwest to the southeast, forming a broad strip ranging from 5 to 25 km in width. These soils are classified within the Entisols order and are characterized by indistinct horizons within their profiles, a result of limited soil-forming activity, and a predominantly light color. They are characterized by a sand content of 85% and a clay content of 10% (Al-Zubaidi 1992). Desert and arid soils constitute the most extensive and widespread soil groups in Iraq, owing to low and irregular rainfall and low organic matter content; these soils are also subject to the influence of wind and flash floods (Al-Akidi, 1990). The sandy soils in the areas west of Basra are recently formed, undeveloped soils. They lack a distinct particle distribution pattern and are dominated by sand-sized particles; their texture ranges from medium-coarse to coarse, according to the American classification system. These sandy soils are well-aerated and exhibit rapid drainage due to a high proportion of macropores (Al-Atab, 2008).

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Study Area:

The North and South Rumaila fields are giant Iraqi oil fields located in the western part of Basra Governorate. They constitute a subsurface geological structure, specifically an anticline, discovered through geophysical methods. This structure is not clearly discernible at the surface. Its topographic gradient is gradual, extending from the Kuwaiti border toward the northwest, passing the Hammar Marsh and moving onto land, and then toward the west, covering a distance of over 100 kilometers. The structure varies in width, reaching up to 18 kilometers, and is asymmetrical in nature. The dip of its eastern flank is gentler than that of its western flank. The angle of dip does not exceed 3 degrees, and the structural relief is 700 feet; the formation consists of Lower Cretaceous deposits, which constitute the oil-bearing section. The fold complex extends for a length of 70 kilometers and a width of 10 kilometers. It comprises three secondary folds: the North Rumaila fold, South Rumaila fold, and the West Qurna fold (Figure 1).

Geologically, the study area lies within Zubair zone, part of the "Unstable Shelf" of Iraq according to geological subdivisions. The area is primarily covered by recent deposits and the Dibdibah Formation (Upper Miocene–Pleistocene), located in the southwestern part of Basra Governorate in southern Iraq. The Dibdibah Formation constitutes part of Iraq's Western Desert, extending over vast areas in the southern region of the country.

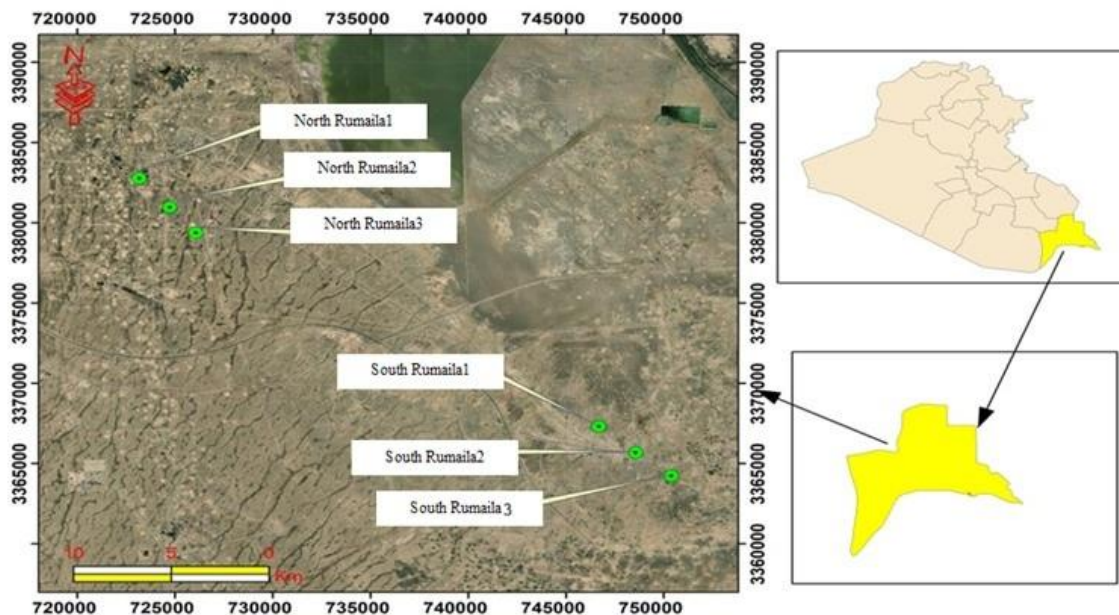


Figure (1) Map of the study area.

2. Materials and Methods

Six samples were collected in December 2024 from the study area (North Rumaila and South Rumaila), with three samples taken from each zone. The first sample site was located approximately 800 meters from the oil facility; the second sample site was located approximately 700 meters from the first; and the third sample site was located approximately 600 meters from the second. Samples

were collected from the surface layer at a depth of 0–30 cm, placed in polyethylene bags, transported to the laboratory, air-dried at room temperature, and subsequently analyzed.

Soil physical properties were measured as follows: soil particle size distribution was determined using the hydrometer method, with temperature correction (without gypsum removal), as described by (Black,1965). Soil bulk density was estimated using the cylinder method, as described by (Black,1965) Particle density was determined using a pycnometer, as described by Black,1956). Gypsum content was measured via acetone precipitation, followed by measuring the electrical conductivity of the resulting precipitate, as described by Bower and Huss (Bower, 1985). Calcium carbonate content was measured using the calcimeter method, which involves measuring the pressure of carbon dioxide released upon the decomposition of calcium carbonate with 6% hydrochloric acid (Jakson 1985).

Regarding chemical properties, analyses were conducted according to the following methods: Soil reaction (pH) was measured in the soil extract using an HQ 411D pH meter (Jakson 1985). Electrical conductivity (EC) was measured in the soil extract using an HQ430d Flexi EC meter at 25°C, as described by (Page et al.,1982) Organic matter was estimated using the Walkley-Black method, involving the oxidation of the soil sample with 1N potassium dichromate and sulfuric acid, followed by titration with 1N ferrous ammonium sulfate, as described by (Jackson, 1985)

3. Results and Discussion

Physical Properties

Table 1. physical properties of the studied soil

location	sand	clay	silt	Bulk Densit (gcm ³)	True Densit (gcm ³)
South Rumaila 1	72.60	17	10	1.5	2.65
South Rumaila 2	60.41	28	11	1.4	2.5
South Rumaila 3	72.84	19	7	1.55	2.63
Nouth Rumaila 1	82.07	15	6	1.6	2.7
Nouth Rumaila 2	70.92	8	21	1.43	2.55
Nouth Rumaila 3	81.71	11	7	1.58	2.52

Particle Size Distribution:

The results regarding the study area indicate the following distribution of soil particles: Sand particles were dominant, reaching their highest proportion (82%) in the North Rumaila area (Site 1), as shown in Table (1) Figure (2). This was followed by the proportion of clay particles, which reached a maximum value of 28% in the South Rumaila area, as shown in Table (1) Figure (3). Next was the

proportion of silt particles, which peaked at 21% in the North Rumaila area (Site 2), as shown in Table (1) Figure (4). The variation in particle content across the study sites is attributed to differences in their deposition times, which leads to limited pedogenic processes, due to the adverse effects of prevailing environmental factors, specifically aridity, the short duration of soil formation, and the nature of the parent material (Al-Ani,2006).

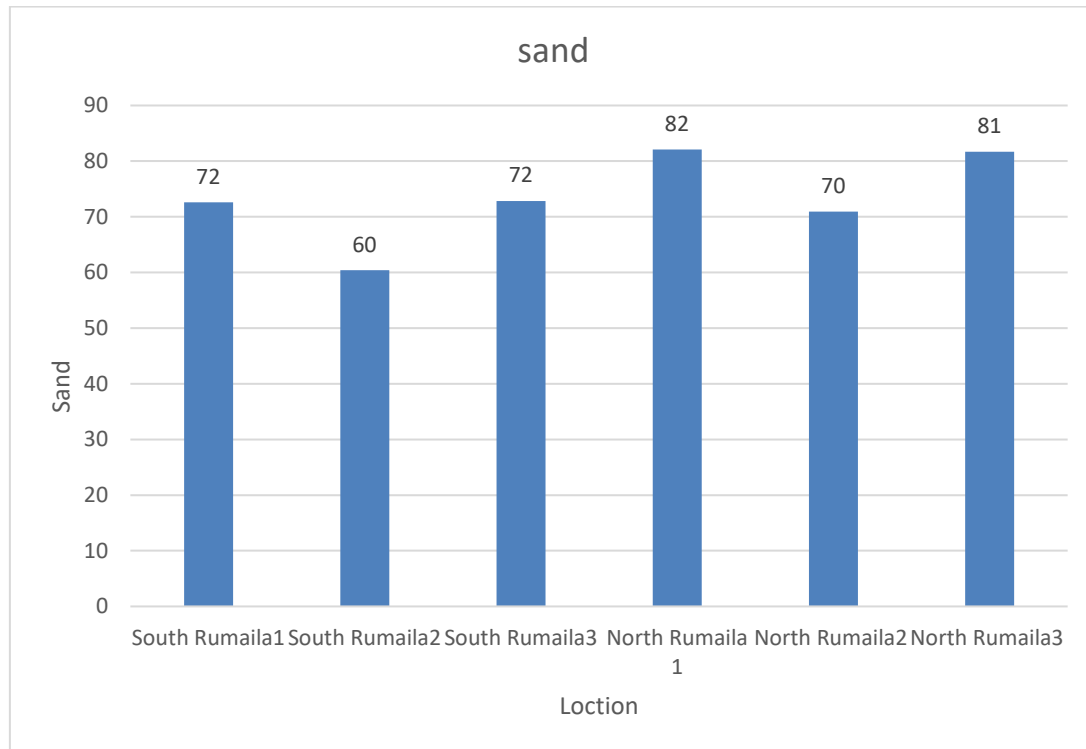


Figure (2) Sand distribution in the study areas.

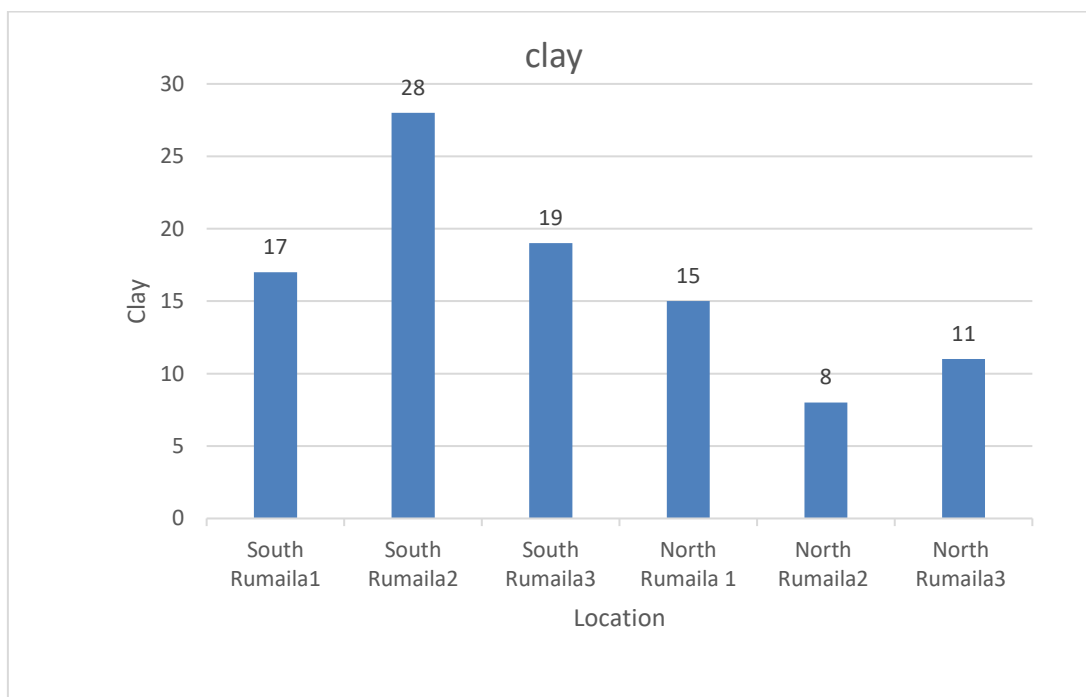


Figure (3) Clay distribution in the study areas.

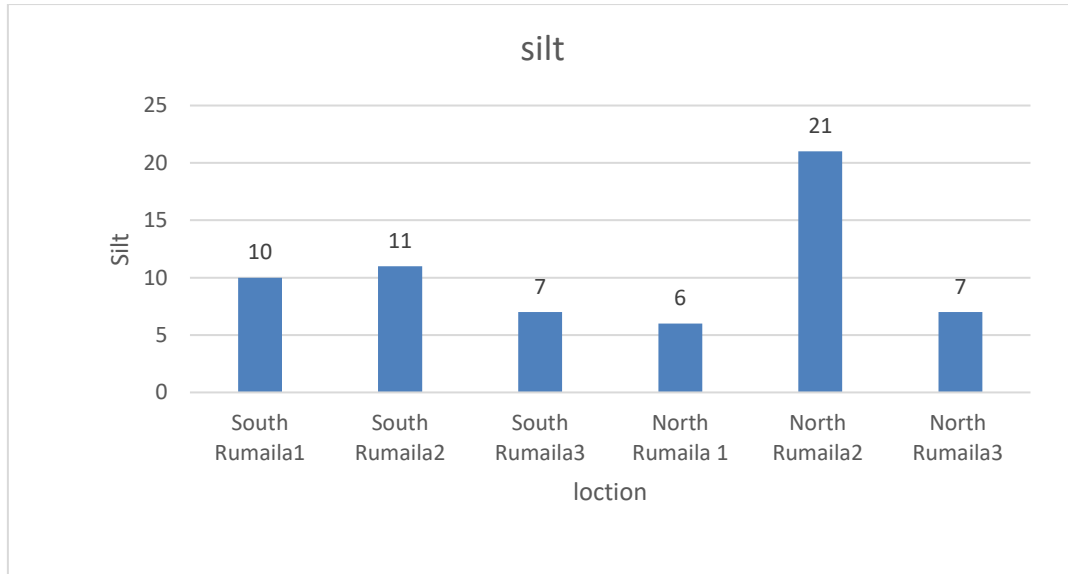


Figure (4) Silt distribution in the study areas.

Bulk Density:

The study results indicated high bulk density values, with the highest value recorded at the first site in the North Rumaila area (1.67 g/cm^3) Table (1) (Figure 5). This high bulk density is attributed to the high proportion of sand particles within the soil texture fractions, a finding consistent with (Al-Ani ,2006).

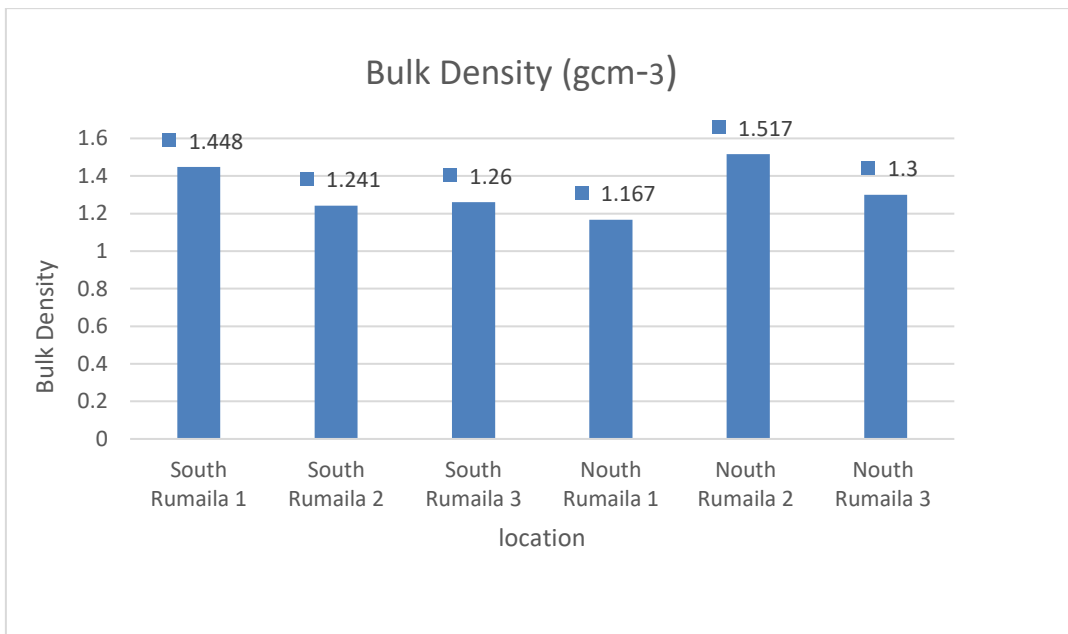


Figure (5) Bulk Density in the study areas.

True Density:

The study results indicated an increase in true density values, with the highest value recorded in the northern sandy area (Site 1) at (2.7 g/cm³) Table (1) (Figure 6). This is attributed to the fact that low organic matter content in the soil leads to an increase in bulk density (Al- Hayali, 2012).

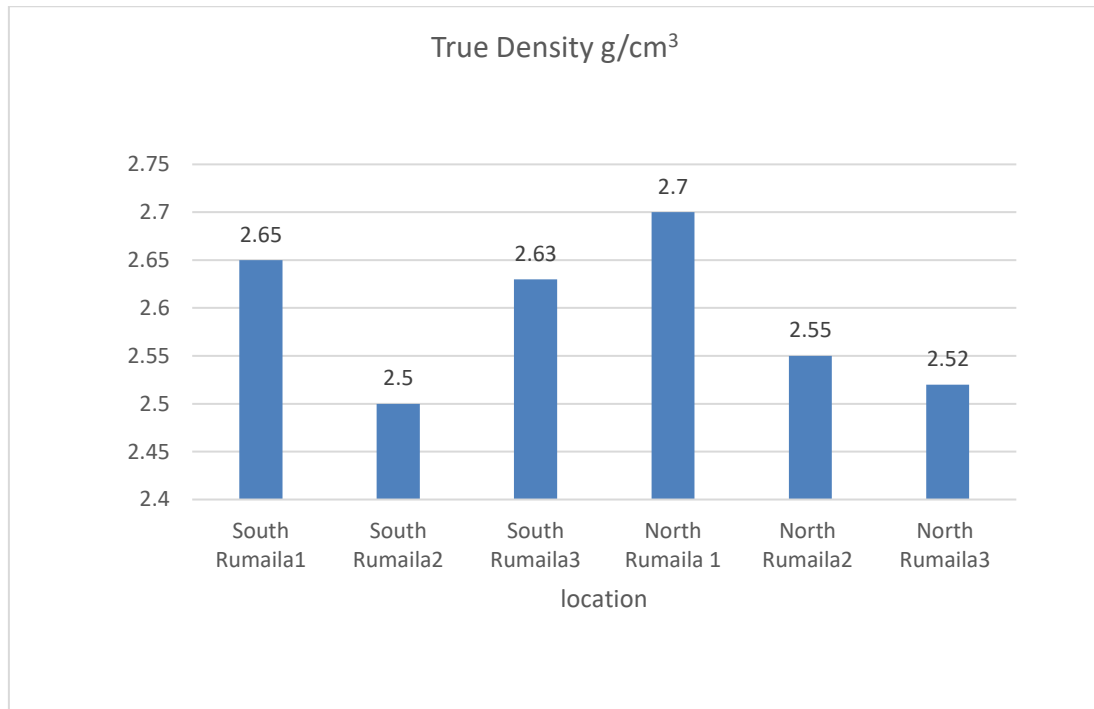


Figure (6) True Density in the study areas.

Chemical Properties

Table 2. Chmical properties of the studied soil

location	pH	EC ds/cm	O.M	CaCO ₃	SaCO ₄
South Rumaila 1	7.45	0.78	0.81	2.5	1.11
South Rumaila 2	7.75	1.55	1.8	4.12	2.06
South Rumaila 3	7.35	1.41	0.9	6.12	2.32
Nouth Rumaila 1	7.43	0.03	0.56	14.23	1.58
Nouth Rumaila 2	7.31	0.68	1.24	7.29	1.32
Nouth Rumaila 3	7.3	0.05	1.5	9.36	1.84

Organic Matter:

The study results indicated a low organic matter content in the soils of the study area, with values ranging from 0.5 to 1.8 Table (2) (Figure7). This is attributed to the predominance of sand particles,

large pore sizes, low rainfall, high temperatures, and sparse vegetation cover, factors that enhance the oxidation of organic matter and accelerate its decomposition (AlShahmani,2020).

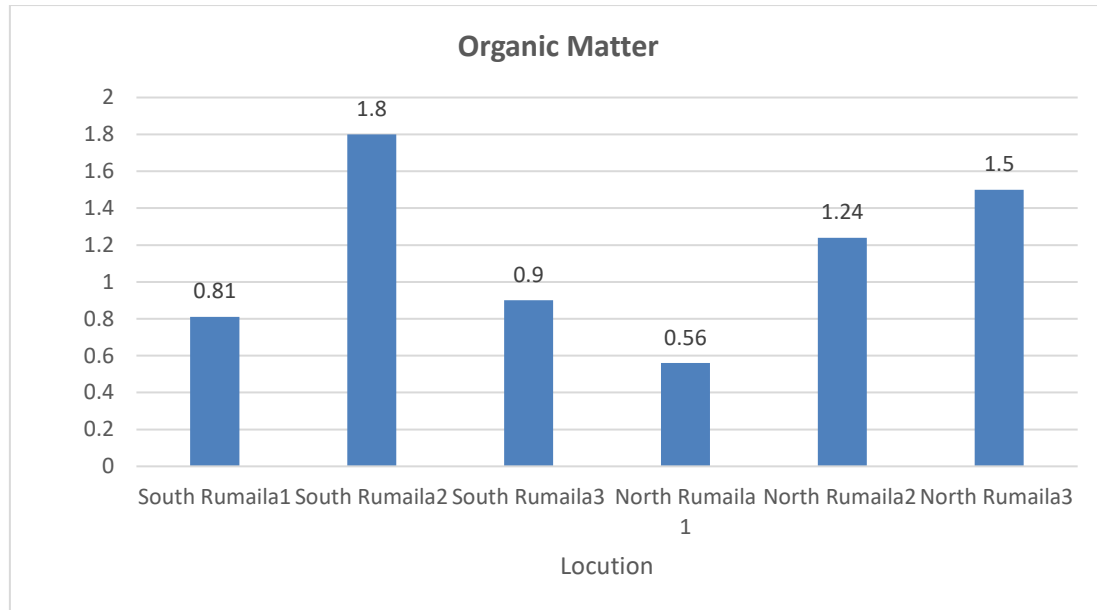


Figure (7) Organic Matter in the study areas.

Electrical Conductivity:

The study results indicated a decrease in electrical conductivity values, which ranged from 0.03 to 1.55 dS/m Table (2) (Figure 8). This low electrical conductivity may be attributed to the depth of the groundwater and the soil texture, which is dominated by sand particles, as well as rainfall, which facilitated the leaching of salts away from the surface layers (FAO 1985)

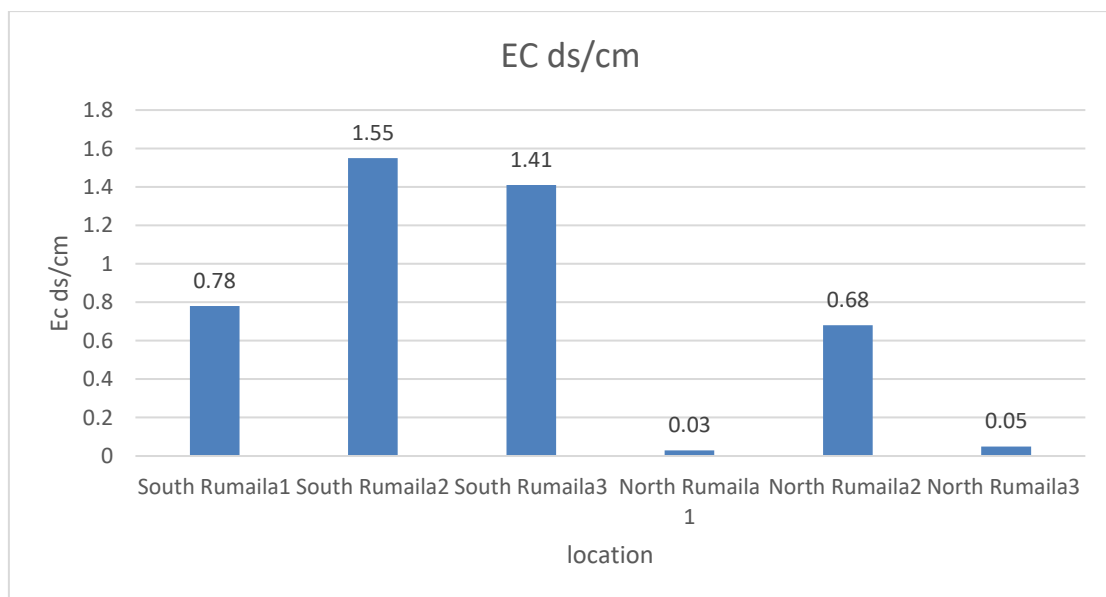


Figure (8) Electrical Conductivity in the study areas.

Soil pH:

Table (2) Figure (9) shows that soil reaction values ranged from 7.30 to 7.75, placing them within the slightly alkaline category according to the US classification [12]. This is attributed to soil texture, salinity, and the content of calcium carbonates and calcium sulfates, as noted by (Presley *et al.* 2004) in their study of soils in arid and semi-arid regions.

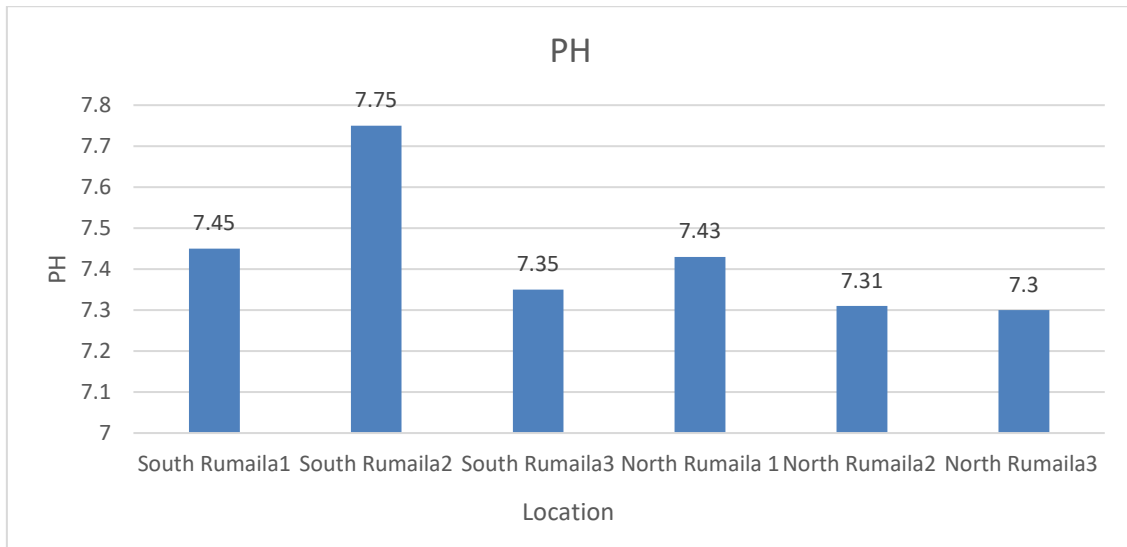


Figure (9) Soil pH in the study areas.

Calcium Carbonate (CaCO_3):

Table (2) Figure (10) shows that calcium carbonate values ranged from 2.5 to 9.36%, with values decreasing with depth in sandy soils. This is attributed to depositional conditions and the quantity of transported material over various time periods, as well as the geological composition of the study area, which consists of sandy, gravelly, and calcareous materials (Buring,1960).

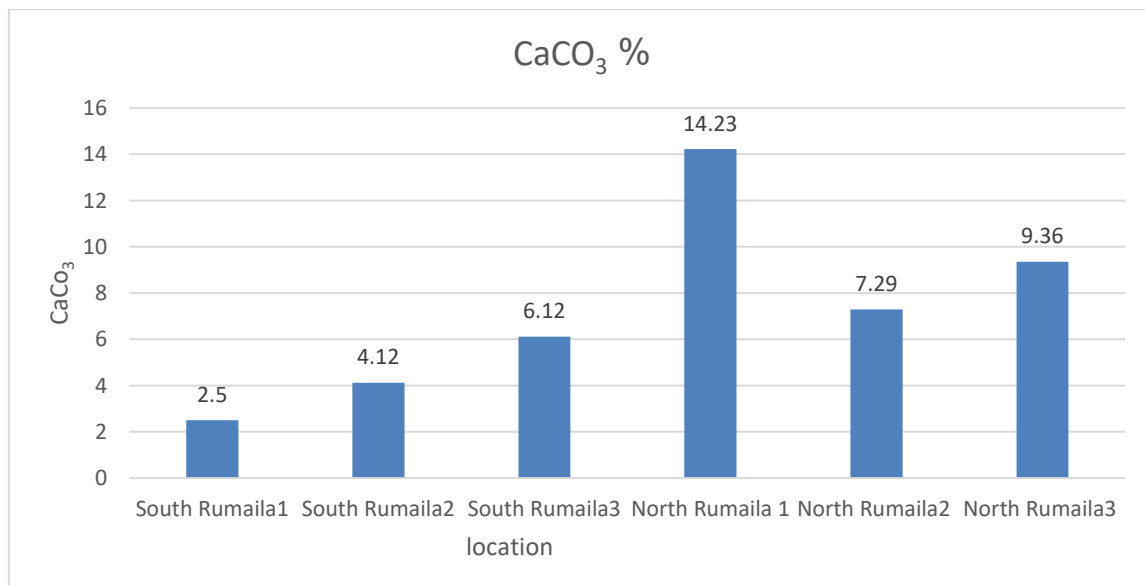
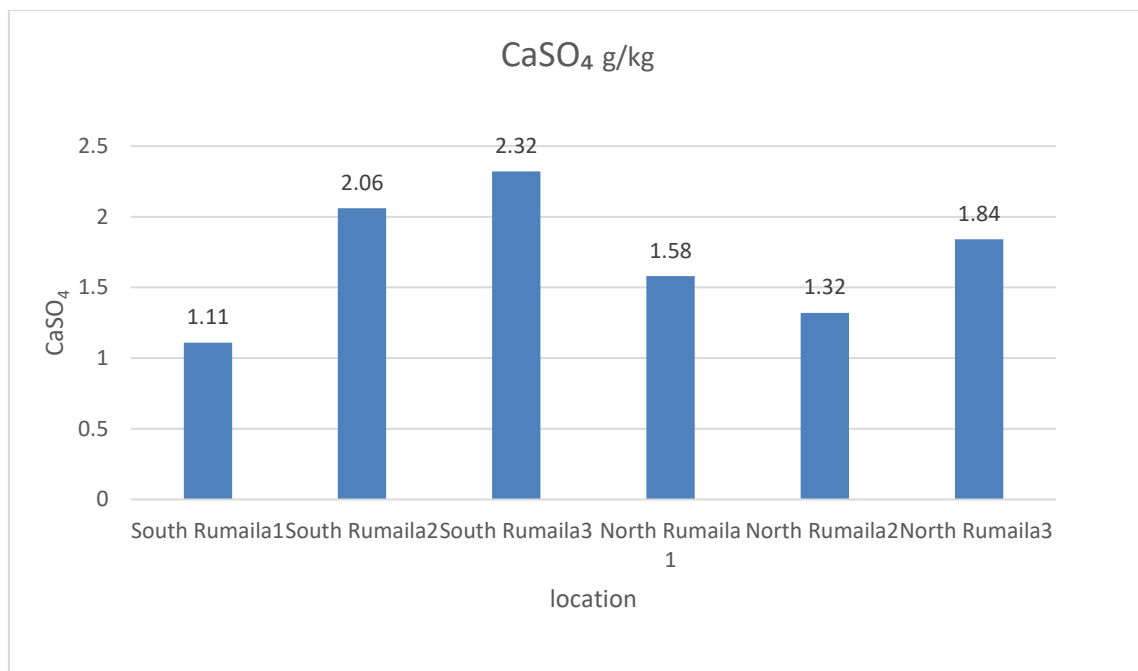


Figure (10) Calcium Carbonate (CaCO_3) in the study areas.**Calcium Sulfate (Gypsum):**

Table (2) Figure (11) shows that calcium sulfate (gypsum) values ranged from 1.11 to 2.32 gm kg^{-1} . Calcium sulfate levels are lower in coarse-textured soils and where the groundwater table is deep. These conditions do not favor salt retention; consequently, the results align with the observed low electrical conductivity values. These findings are consistent with (Yahia,1971) who noted that coarse-textured soils have a lower salt content compared to fine-textured soils.

**Figure (11) (Gypsum (CaSO_4) study areas.****Conclusions:**

The soil is of recent deposition, influenced by arid conditions and the limited duration of pedogenic processes, resulting in a variable distribution of coarse particles. Bulk density (1.6 g/cm^3) and particle density (2.7 g/cm^3) reflect the predominance of sand and low organic matter content (0.5-1.8%), driven by high temperatures and low rainfall. Electrical conductivity ranges from 0.03 to 1.55 dS/m, influenced by the coarse texture, groundwater depth, and the leaching effect of rainfall. The soil tends to be slightly alkaline (pH 7.30-7.75), with low levels of calcium carbonate (decreasing with depth) and calcium sulfate (gypsum), consistent with the soil's coarse nature.

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