Spatial Variation in Soil Fertility Levels in the Sayed Ahmed Al-Rifai and Al-Salam Sub-Districs of Southern Iraq

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Abstract

This study aims to identify the spatial variation in soil fertility levels in the Sid Ahmed al-Rifai and al-Salam sub-districts of southern Iraq. Sixteen soil samples were collected and sent to the Youscience Scientific and Chemical Laboratory for analysis of fertility levels (organic matter % and NPK elements (ppm)) . The coordinates of these samples were determined using a GPS device and plotted on a map of the study area, where the results of the laboratory analyses were compared with soil classification standards based on organic matter content and nutrient concentration levels (N, P, K) **.** The soils in the study area varied according to their fertility levels of organic matter, it was found that approximately (894.3) km^2 of soils located within the (medium) rating, representing (54.1%), while the largest proportion of nitrogen concentration (965.8) km^2 located within the (low concentration) rating, representing (58%). As for the phosphorus element, about (808.6) km^2 located within the (low concentration) assessment, with a percentage of (48.8%). Finally, the potassium element, about (894.3) km^2 located within the (low concentration) assessment, with a percentage of (54%). The results showed that the soils of the study area suffer from a deficiency of fertility elements (N.P.K) in general. Therefore, it is recommended to develop appropriate organic and mineral fertilization programs to provide the elements in particular to increase their fertility levels.

Keywords: Soil fertility, Potassium concentration, Spatial variability, Geochemical analysis, NPK

1. Research problem

This can be determined by the following question:

(What is the level of spatial variation in the organic matter and fertility content of the soils in the sub-distics of Sayed Ahmed Al-Rifai and Al-Salam?).

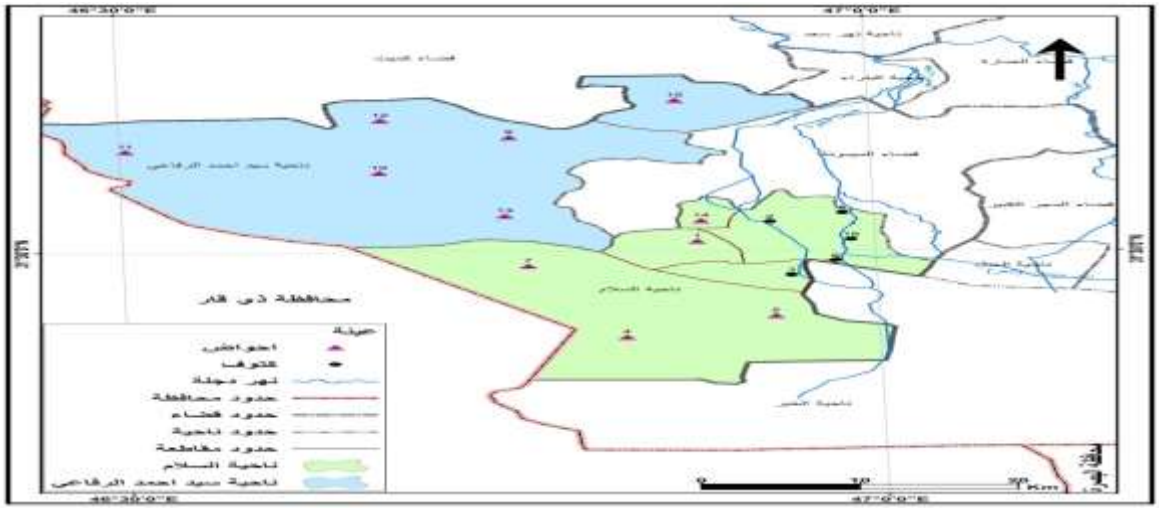
2. Research hypothesis

This study hypothesizes that there is a spatial variation in the fertility levels of the soils of Sayed Ahmed Al-Rifai and Al-Salam sub-districts, according to the variation in their physical and chemical properties.

3. Location and boundaries of the study area

The study area, comprising the sub- districts of Sayyid Ahmad al-Rifai and al-Salam, which are affiliated with the Maymuna district in Misan province in southern Iraq, is located in the southern part of the alluvial plain, specifically between latitudes (17°41′–31°5′) – (2°15′–31.5′) north and longitudes (11°39′–46.5′) – (28°2'–47°5' E). It is bordered to the north by the Kamit sub-district, to the west by Dhi Qar province, to the south by the Al-Khair sub- district, and to the east by the Al-Maymuna district center. The study area covers approximately (1,656.9) km², which is approximately (10.3%) of Misan province, which has a total area of (16,027) km². A total of (16) soil samples were collected from the study area, as shown in Map (1), with six samples from the Sayyid Ahmad al-Rifai sub-district and twenty samples from the al-Salam sub-district.

Map (1): Spatial distribution of the studied soil samples in the sub-districts of Sayyid Ahmad Al-Rifa'i and Al-Salam



Source: The researchers, based on field survey data using a Global Positioning System (GPS) device.

Chapter 1: Soil fertility and its types in the sub- districts of Sayyid Ahmad al-Rifai and al-Salam First- soil fertility and the factors affecting it:

Soil fertility is one of the important foundations that must be observed in soil management programs, and soil fertility work may be one of the first tasks that must be evaluated in any agricultural project as it relates to production and how to control its direction (Al-Akidi,1990) . Fertility is considered an essential element for soil and plants, and it is of two types. The first is natural fertility, which is clearly represented by the complex and dynamic interactions between the physical, chemical, and biological properties of the soil, which expresses the state of the soil system that has developed through the natural processes of soil formation. The second type is acquired soil fertility which indicates the ability of the soil to provide plants with the necessary nutrients as a result of human interventions (Khan,2018)

Soil fertility also depends on its organic components, which play an important role in the formation of fertile soils by providing essential nutrients required for plant growth, such as nitrogen, calcium, phosphorus, and magnesium. The dead tissues of living organisms represent the primary source of food for soil microorganisms, which live within the soil and play a vital role in the decomposition of organic matter. This process results in the production of complex acids that in turn contribute to breaking down mineral materials into small, soluble particles (Al-Mudhaffar ,n.d.) .

In line with the above, soil fertility can be defined as the natural capacity of soil to supply plants with the essential nutrients necessary for their proper growth. This fertility reflects the amount of available nutrients in the soil, which originate from mineral elements derived from the rocks of the earth's crust (Abu Samour and Ghanem,1998).

Factors affecting soil fertility:

There are several factors that negatively affect soil development and increasing its fertility. On the contrary, soil may be fertile because of its adequate and sufficient content of essential nutrients required for plant growth; However, it may still not be productive. This may be because it contains harmful salts that prevent plant growth, or because of the poor composition of mineral nutrients that plants need. Therefore, such soil requires reclamation before cultivation practices can be carried out. Among the most important factors affecting agricultural soil Soil depth or the volume that plant roots can exploit, (fertility, the following can be identified Al-'Awad, 1987). and drainage, as most crops cannot tolerate waterlogging. Water availability, i.e. constant supply of water to maintain soil moisture. Aeration is one of the essential factors for healthy root growth and high biological activity of soil organisms .The mineral composition of soil depends on the amount of nutrients released through physical weathering processes, as well as the structure of the soil and its ability to retain nutrients. Soil reaction (pH) is one of the main factors that determine soil fertility, as it is necessary that the soil is neither too acidic nor too alkaline (Abdelrahman,2025)..

In conclusion, soil fertility depends mainly on organic matter due to its vital role in soil formation. It is considered an important source of nutrients, which are released in available forms during decomposition processes. In addition, it contributes indirectly to improving the quality and properties of the soil, as it is an effective factor that, when present, helps in the formation of well-organized soil (Al-Salem,1989).

Second: Soil Types in the Sayyid Ahmad al-Rifai and al-Salam sub- district:

The soils of southern Iraq in general, and the study area in particular, are characterized by a highly degree of homogeneity and regularity compared to those of the northern regions. The size of the soil particles varies, with a clear tendency towards fineness, meaning that the soil becomes more cohesive and homogeneous as one moves south and east. These soils are also characterized by high fluidity (friable soil), an important property in agricultural processes and seed germination, as it facilitates the penetration of plant root hairs into the surface soil layers.

The southern soils contain a full range of essential nutrients necessary for plant growth, and they can be improved and reclaimed through modern agricultural techniques and sound farming practices. It is worth noting that these soils contain a high percentage of calcareous materials, along with other components that form the basic structure of the soil, such as organic matter, nitrogen, phosphorus, and potassium, with low levels of soluble toxic salts (Al-Saadi,2009).

The soils of the study area are classified as follows:

1. River levee soils:

These soils extend along both sides of the branches of the Tigris River in the study area, represented by the (Al-Batira and Al-Arid) channels and their secondary branches up to their confluence points. They are characterized by a medium-textured structure and good drainage due to their elevation above the surrounding lands (Fanjan,2021). They are also the highest soils, with an average depth ranging between (2–3 m) above the level of adjacent basins; therefore, they are considered among the best soil types in the study area.

These soils were formed as a result of the fluvial processes of the Tigris River where floodwaters carrying sediments and rock fragments overflowed during the flood stage, leading to their deposition outside the river channel boundaries. When the flow velocity decreases and its transport capacity declines, sedimentation begins, resulting in a depositional form that is relatively higher compared to the inner parts of the floodplain

2. River basin soils:

These soils are characterized by their relatively low elevation, ranging between(2 and 3 m). They are found in locations relatively far from and at lower elevations than the main river channels and irrigation canals branching

off the Tigris River extending along the irrigation canals in the study area. These soils lie below the level of the dams and adjacent irrigation canals.

These soils were formed as a result of the accumulation of fine sediments transported by floodwaters over long distances from their original courses, leading to their deposition in topographic depressions (Al-Kaabi,2021). They are characterized by a fine-grained texture. When sufficient water is available, they may transform into marshes, and the groundwater level is naturally high. During certain times of the year, their surface suffers from poor drainage and high salinity levels, and when they dry out, these soils become prone to cracking (Al-Qarah Ghuli,2020) .These soils occupy large areas, with a total area of (1203.7 km²), representing (72.7%) (Map 2).

4. Marsh and Swamp Soils:

This type of soil is found in marshland and swamp areas, represented by the presence of (Al-Battat marsh, Al-Khams marsh , and Al-Dhala‘ marsh), which are spread across the western parts of the study area. These areas are considered the lowest lands where the distributaries of the Tigris River terminate. These soils are of recent formation (Al-Jassim and Karim, 2022).

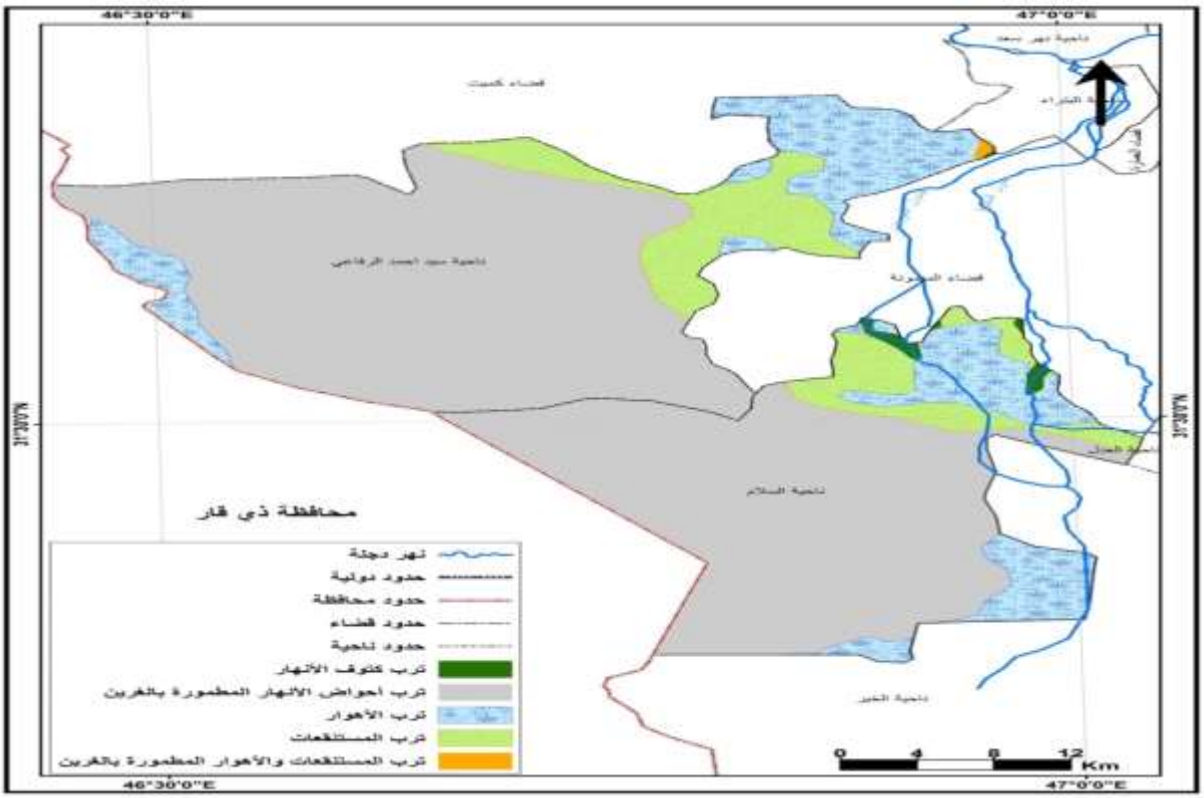
The quantities of sediments forming marsh soils vary according to sedimentation processes and the materials carried by tributaries flowing into the marshes. In general, these soils mainly consist of silty clay loam, which represents the primary component of these deposits, along with the presence of several rare minerals mixed within them (Khalaf, 2017).

These soils are highly fertile and are locally referred to as (Al-Talla land). However, they have been affected by human activities particularly through interference in water flow, which has limited the amount of sediments that can reach these areas (Saad,2014).

Marsh soils are characterized by several physical properties, including their fine texture and high capacity to retain nutrients in forms readily available to plants. This is due to the large specific surface area of their particles, as well as their high water-holding capacity resulting from their small particle size and large surface area. Despite these advantages, they also have some drawbacks, such as poor aeration and difficulty for plant roots to penetrate and spread through their layers.

Regarding their chemical properties, these soils are characterized by the dense growth of aquatic plants, which accumulate year after year and decompose to form organic matter. The high organic matter content gives these soils their distinctive properties, as it acts as a reservoir of essential nutrients required by plants. It also contributes to improving soil aeration, structure, and reducing bulk density, thereby increasing permeability and water retention capacity (Saad,2023). The area of these soils within the study region is approximately 440.2 km², representing about 26.6%, as shown in Map (2).

Map (2): Soil types in the Sub-district of Sayed Ahmed Al-Rifai and Al-Salam**.**



Buring, P. Soils and Soil Condition in Iraq, Ministry of Agriculture, Baghdad, 1960, P.75.

Chapter Two: Spatial Variation of Soil Organic Matter Content and Nitrogen, Phosphorus and Potassium Elements in the Sub- Sub-district of Sayed Ahmed Al-Rifai and Al-Salam.

First - Organic Matter (OM)

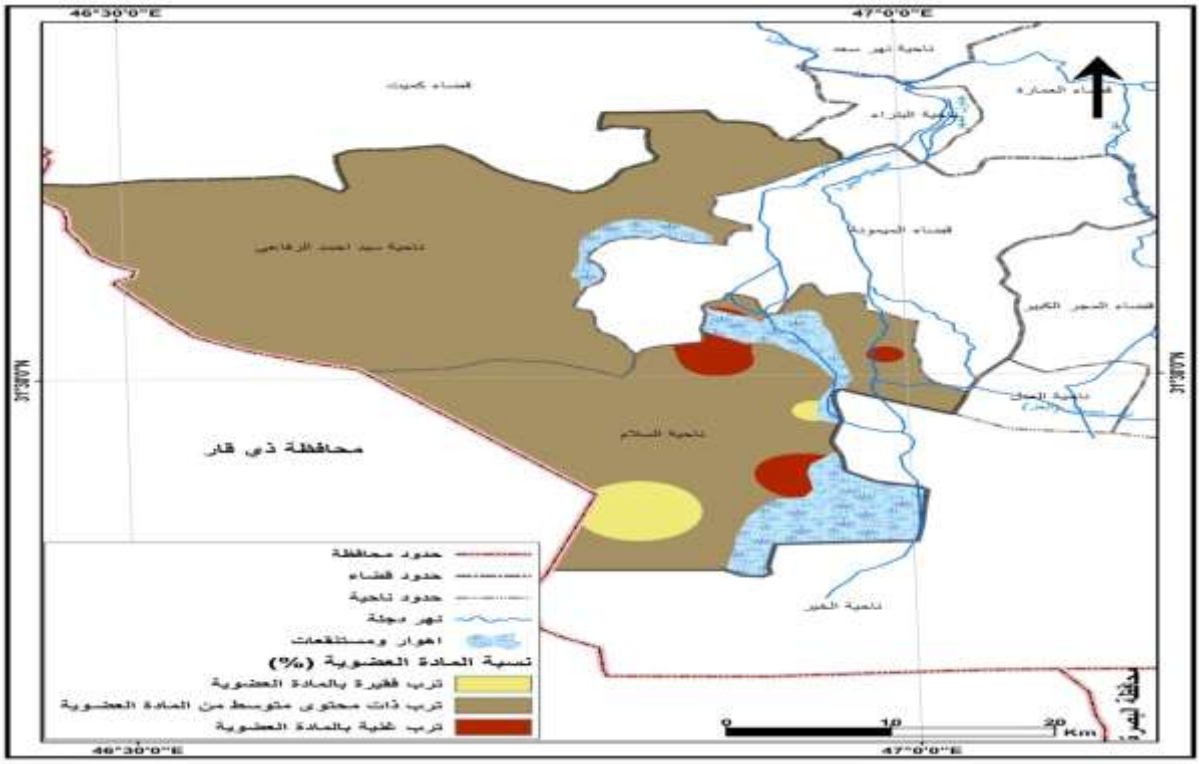
The results of the chemical analysis of soil samples, as shown in Table (1) and Map (3), indicate a variation in the values of organic matter in the study area**.**

Table (1): Organic Matter Content (%) of Soils in the Sub-districts of Sayyid Ahmad Al-Rifa'i and Al-Salam.

S	Location	%OM
1	Al-Burjman (7)	2.18
2	Al-Duwaymah and Al-Shati (2)	1.28
3	Al-Khams and Al-Qatta' (8)	0.82
4	Al-Ruwayda and Al-Shattabiya (9)	0.64
5	Al-Khams and Al-Dala'a (8)	2.39
6	Abu Najha and Bayda (4)	1.52
7	Al-Burhan (Third) (7)	1.53
8	Al-Rafi' (17)	1.41
9	Village Umm 'Aida (11)	1.42
10	Khalfat Al-Mirbad (11)	1.51
11	Al-Sabiya (11)	1.28
12	Al-Aqeel (11)	1.25
13	Al-Khaifa (11)	1.35
14	Al-Rafiya (5)	2.43
15	G4	1.57
16	Al-Rafi' (Second) (17)	2.11

Source: The author's work is based on the results of laboratory analysis of soil samples from the study area, which were analyzed at the (Youscience Scientific Laboratory) in November 2025.

Map (3) Organic Matter Content of the Study Area(%)



Source: Researcher based on data from Table (1) and ArcMap V10.8 software

The soils of the study area can be classified according to their organic matter content through the criterion of this property in Table (2).

Table (2) Soil types according to their organic matter (OM) content %

Classification	Organic Matter Content (%OM)
Poor in organic matter	< 1
Moderate organic matter content	1 – 2
High organic matter content	> 2

Source: Muzaffar Ahmad Al-Mawsili and Qahtan Darwish Al-Khafaji, Fundamentals of General Education, Al-Waddah Printing and Publishing House, Amman, 2014, p. 34.

In order to obtain more detailed data on the spatial variation of the organic matter content of the soils in the study area, this variation can be reviewed according to the physiographic units of the soils in the study area as follows:

1. **River level soils:**

The overall mean value of organic matter content in the river levee soils of the study area was (1.43%). These values showed spatial variation among the studied samples and districts, in addition to variation according to administrative units. The maximum value reached approximately (2.10%) for sample (16) within district (17), known as (Al-Rafee' Al-Thaniya), which administratively belongs to Al-Salam sub-district. This area located within the category of (soils rich in organic matter).
The minimum value was (0.82%) for sample (3) within district (8), known as (Al-Dhla' and Al-Khams), which also belongs administratively to Al-Salam sub-district. This area located within the category of (soils poor in organic matter) From Table (1), it can be inferred that the variation in organic matter content in river levee soils is due to several factors, including differences in vegetation cover within the study area. Vegetation contributes to the accumulation of plant residues and their decomposition, which leads to their breakdown in the surface soil layer and enriches the soil with organic matter. Naturally, most organic matter is concentrated in this surface layer.

2. River Basin Soils:
Table (1) shows a variation in the organic matter content of river basin soils. The overall average for these soils in the study area was (1.53%). The highest organic matter content (2.39%) was recorded in Sample (5) within District (8), known as (Al-Dha'al and Al-Khams) which administratively located the Al-Salam sub-district. This area is classified as having soils rich in organic matter The lowest percentage (1.25%) was recorded in Sample (12) within District (11), known as (Al-Aqeel Village) which administratively located the Sayyid Ahmad Al-Rifai sub-district. This percentage is classified as having soils with medium organic matter content. From these data, it can be concluded that the organic matter content of river basin soils varies spatially within the study area. This variation is mainly attributed to differences in vegetation cover, which is relatively better in some areas compared to others. consequently, these areas exhibit higher organic matter content, while areas with less vegetation cover show lower organic matter content. It is also important to note the hot climatic conditions that characterize the study area, which accelerate the decomposition and oxidation of organic matter. This is accompanied by a decrease in rainfall, leading to reduced vegetation cover and thus contributing to lower overall levels of organic matter.

3. Marsh and Swamp Soils:
The average organic matter content in these soils was (1.75%). The highest value (2.43%) was recorded in sample (14) from area (5), known as (Al-Rafashiya) administratively part of Al-Salam sub-district. This area is classified as having soils rich in organic matter. The lowest value of organic matter in marsh and swamp soils was (0.64%), recorded in sample (4) from area (9), known as (Al-Ruwaida and Al-Shattaniya) administratively part of Al-Salam sub-district. This area is classified as having soils poor in organic matter. Table (1) shows that the organic matter content in marsh and swamp soils varies spatially. The relatively high organic matter content is attributed to the aquatic environment of the marshes, which provides favorable conditions for plant growth. This, in turn, leads to an increase in soil organic matter through the continuous decomposition of plant remains after their death, in addition to the decomposition of various organisms. However, the variation in these values is attributed to several factors, including the draining of marsh and wetland areas, coupled with decreased rainfall and increased temperatures. Furthermore, the use of hazardous chemicals for vegetation removal, as well as burning practices, have contributed to spatial variations in organic matter content across these regions.

Second - Nitrogen (N):
The results of the chemical laboratory analysis of soil samples in the study area for nitrogen concentration showed variations in this concentration across different parts of the study area and at the level of the studied districts (Table 3, Map 4) Based on this data, the soils of the study area were evaluated according to their nitrogen content (Table 4), which was adopted as a standard for nutrient concentration (NPK).

Table (3) Nitrogen content of the soil in the study area (ppm)''

(S)	**(District/Area)**	**(Nitrogen – ppm)**
1	Al-Burhan Al-Oula (17)	15.4
2	Al-Duwayma & Al-Shati / (2)	14
3	'Al-Khums & Al-Thala / (8)	11.2
4	Al-Ruwaida & Al-Shattaniya / (9)	10.5
5	Al-Khums & Al-Thala' / (8)	16.8
6	Abu Na'ija & Abu Shiha / (4)	12.6
7	Al-Burhan Al-Thaniya / (7)	16.8
8	Al-Rafie / (17)	18.2
9	Umm Ubaida (District / (11)	18.9
10	Khalf Al-Marqad (District 11)	9.8
11	Al-Sabila (District 11)	19.6
12	Al-Akeel (District 11)	11.2
13	Al-Khalifa (District 11)	14.7
14	Al-Raqashiya / (5)	15.4
15	L4	14

16	Al-Rafie Al-Thaniya / (17)	15.4

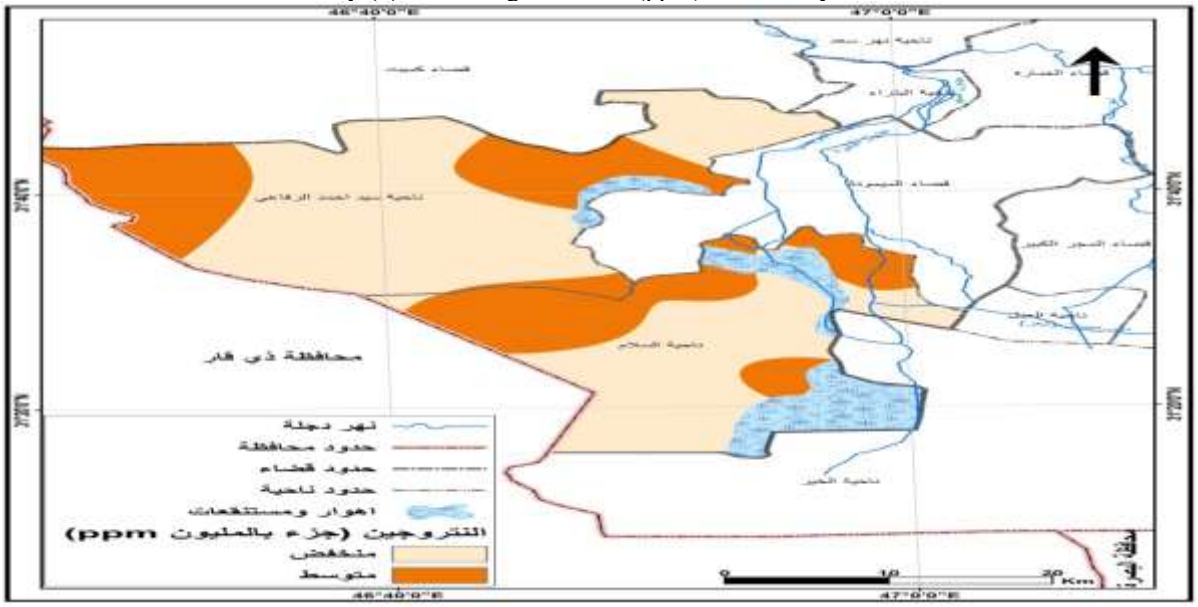
Source: The researcher, based on the results of laboratory analysis of soil samples from the study area, which were analyzed in the (Youscience Scientific Laboratory) November 2025.

Table (4) Standard for nutrient concentration in soil (ppm)

Element	Very low	Low	Medium	High	Very high
Nitrogen	0-5	5-15	15-30	30-40	40>
Phosphorus	0-3	3-8	8-14	14-20	20>
Potassium	0-85	85-150	150-250	250-450	450>

Source: Guide to Fertilizer Use in the Middle East, Food and Agriculture Organization of the United Nations, Rome, 2007, p. 184.

Map (4) Soil nitrogen content (ppm) in the study area.



Source: Researcher based on data from Table (7) and ArcMap V10.8 software

At the level of natural units, the values of the nitrogen element were distributed as follows:

1. River levee soils

The overall mean value of nitrogen in the river levee soils of the study area was (14.28 ppm), while the maximum value reached about (18.2 ppm) recorded in sample (8) within district (17) (Al-Rafi' Al-Ula) administratively belonging to Al-Salam sub-district. This area located within the category of moderate concentration. The minimum nitrogen value in river levee soils was about (11.2 ppm), recorded in sample (3) within district (8) (Al-Dala' and Al-Khams), administratively belonging to Al-Salam sub-district. This area located within the category of low concentration (Table 4). From these data, it can be concluded that there is a variation in the concentrations of available nitrogen in the river levee soils of the study area. This variation is attributed to several reasons, including differences in the intensity of agricultural investment in these areas, the use of fertilizers by farmers (urea fertilizer), as well as nutrient losses due to high temperatures, and finally the types of cultivated crops.

2. River basin soils:

The average nitrogen content in river basin soils was approximately (15.4 ppm) with the highest value recorded at (19.6 ppm) in Sample No. 11 (Al-Sabla), administratively belonging to the Sayyid Ahmad Al-Rifai sub-district. This area is classified as having a medium concentration. The lowest nitrogen value in riverbank soils was approximately 9.8 ppm, it was recorded in sample (10) within sector (11), which is administratively affiliated with the center of Sayyid Ahmad Al-Rifai sub-district. This area is classified as having a low concentration (Table 4). From these data, it can be concluded that there is a variation in the concentrations of available nitrogen in the study area. This variation in river basin soils is attributed to the continuous agricultural exploitation of these areas, which necessitates the addition of nitrogen fertilizers by farmers to increase soil fertility. In contrast, lower concentrations were observed in other areas within the study area.

3. Marsh and swamps Soils:

The average nitrogen concentration in the marsh and swamps soils of the study area was approximately (13.8 ppm). The highest concentration was recorded in samples (1 and 14) within the Al-Burhan Al-Awal and Al-Rafashiya districts (17 and 5) areas, administratively affiliated with the Al-Salam sub-district. These areas are classified as having an average concentration. The lowest concentration, approximately 10.5 ppm, was recorded in sample 4 within the Al-Ruwaida and Al-Shataniya (9) disticts, administratively affiliated with the Al-Salam sub-district. This area is classified as having a low concentration (Table 4). It can be concluded from these data, there is a

variation in nitrogen concentrations in the marshes and swamps soils of the study area. This variation is attributed to several factors, including the high clay content and high moisture levels in these soils, which promote the decomposition of organic matter and increase nitrogen concentration. Conversely, continuous leaching and filtration processes lead to the loss of dissolved nitrates, which in turn reduces nitrogen concentration.

Third - Phosphorus (P)

he results of the chemical analysis of soil samples from the study area regarding the concentration of phosphorus, as shown in Table (5) and Map (5), revealed a variation in these values between the areas of Sayed Ahmed Al-Rifai and Al-Salam sub-disticts.

Table (5) Phosphorus content of the soils of Sayyid Ahmad Al-Rifai and Al-Salam sub-districts (ppm).

(S)	(District/Area)	(Phosphours - ppm)
1	Al-Burhan Al-Oula (17)	4.24
2	Al-Duwayma & Al-Shati / (2)	4.62
3	'Al-Khums & Al-Thala / (8)	0.03
4	Al-Ruwaida & Al-Shattaniya / (9)	0.12
5	Al-Khums & Al-Thala' / (8)	0.28
6	Abu Na'ija & Abu Shiha / (4)	5.99
7	Al-Burhan Al-Thaniya / (7)	4.46
8	Al-Rafie / (17)	6.56
9	Umm Ubaida (District / (11)	4.02
10	Khalf Al-Marqad (District 11)	0.02
11	Al-Sabila (District 11)	0.12
12	Al-Akeel (District 11)	10.18
13	Al-Khalifa (District 11)	14.27
14	Al-Raqashiya / (5)	0.24
15	L4	0.14
16	Al-Rafie Al-Thaniya / (17)	4.15

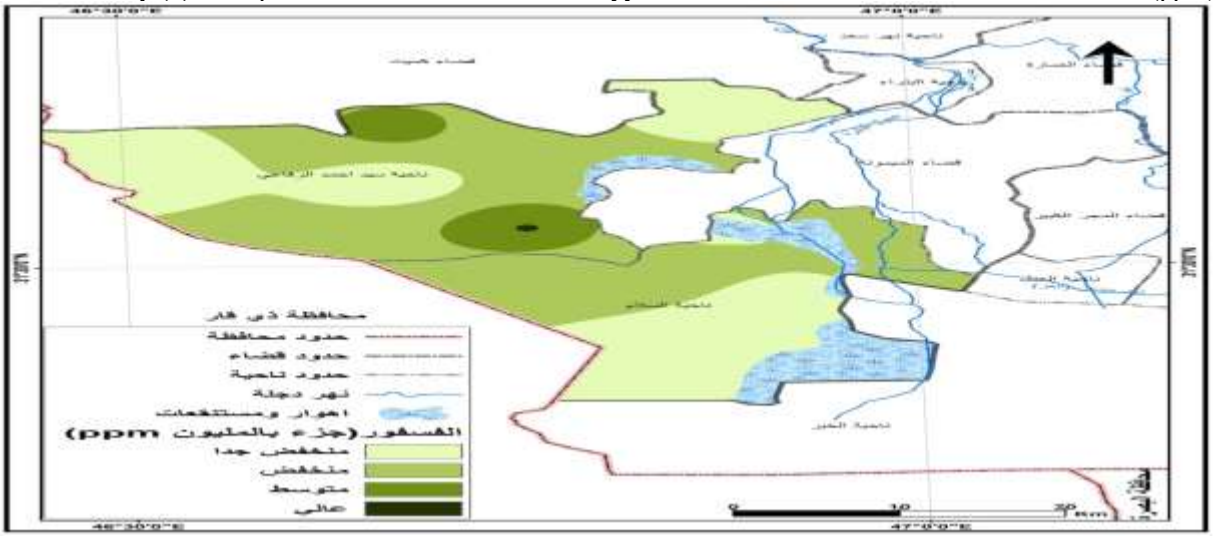
Source: The researcher based on the results of laboratory analysis of soil samples from the study area that were analyzed in the (Youscience Scientific Laboratory), November 2025.

Based on this data, and in order to obtain more accurate details regarding the spatial variations in phosphorus concentration values, they will be studied as follows:

1.River levee soils:

The overall mean value of phosphorus concentration in the river levee soils of the study area was (4.76 ppm) while the maximum value reached (6.56 ppm), recorded in sample (8) located within district (17) (Al-Rafi' Al-Awwal), administratively belonging to Al-Salam sub-district center. This area falls within the category of low concentration. The minimum value was (0.03 ppm), recorded in sample (3) located within sub-district (8) (Al-Khams and Al-Dala), administratively belonging to Al-Salam sub-district center. This area also falls within the category of low concentration (Table 5). The low phosphorus concentrations in river levee soils are attributed to the low use of phosphate fertilizers (DAP) in cultivated areas, or possibly due to leaching processes affecting these soils during successive flooding seasons.

Map (5): Phosphorus Content in the Soils of Sayyid Ahmad Al-Rifa'i and Al-Salam Sub-districts (ppm)



Source: Researcher based on Table (9) and ArcMap V10.8 software

2.River Basin Soil :

The average phosphorus concentration in the river basin soil of the study area was (4.76 ppm). The highest concentration was recorded in sample number 13, located in area (11) (Al-Khalifa area), administratively within the Sayyid Ahmad Al-Rifai sub-district. This sample is classified as having a high concentration. The lowest concentration was 0.02 ppm, recorded in sample number 10, located in area (11) administratively within the Sayyid Ahmad Al-Rifai sub-district. This sample is classified as having a very low concentration (Table 5).

3. Marsh and Swamp Soils:

The average phosphorus concentration in the marsh and swamp soils of the study area was approximately 1.185 ppm. The highest value (4.24 ppm) was recorded in sample (1) within area (7) (Al-Burhan Al-Awwal), administratively within the Al-Salam sub-district. This area is classified as having a low concentration. The lowest value was approximately 0.12 ppm, recorded in sample (4) within area (9) (Al-Ruwaida and Al-Shataniya) administratively within the Al-Salam sub-district. This area is classified as having a very low concentration (Table 5). From these data, it can be concluded that the low phosphorus concentration in the marsh and swamp soils of the study area is due to several factors, including climatic conditions that promote phosphorus fixation in the soil, as well as the clayey nature of the marsh soils, which reduces phosphorus availability. Therefore, a variation in phosphorus concentration was observed among the studied soil samples.

Fourth - Potassium (K):

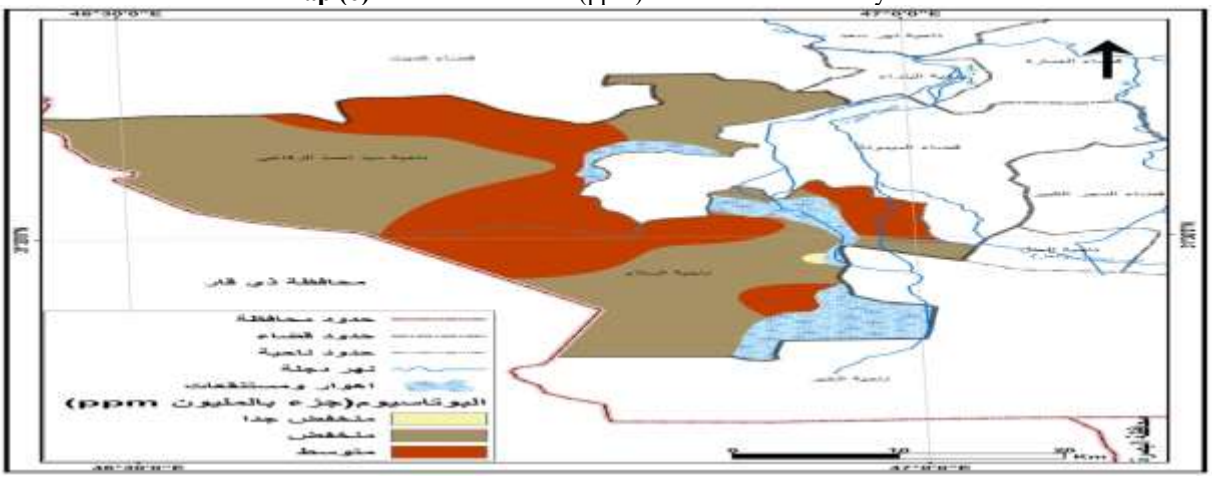
The results of the chemical laboratory analysis of soil samples in the study area for the concentration of phosphorus showed a variation in this concentration in the studied areas. Table (6) and Map (6).

Table (6) The content of the soil of Sayed Ahmed Al-Rifai and Al-Salam sub- districts of the element potassium (ppm**).**

(S)	(District/Area)	(Potassium - ppm)
1	Al-Burhan Al-Oula (17)	161.7
2	Al-Duwayma & Al-Shati / (2)	137.29
3	'Al-Khums & Al-Thala / (8)	73.31
4	Al-Ruwaida & Al-Shattaniya / (9)	124.66
5	Al-Khums & Al-Thala' / (8)	168.43
6	Abu Na'ija & Abu Shiha / (4)	145.71
7	Al-Burhan Al-Thaniya / (7)	155.81
8	Al-Rafie / (17)	163.38
9	Umm Ubaida (District / (11)	170.11
10	Khalf Al-Marqad (District 11)	85.11
11	Al-Sabila (District 11)	144.02
12	Al-Akeel (District 11)	169.27
13	Al-Khalifa (District 11)	176.01
14	Al-Raqashiya / (5)	144.86
15	L4	90.15
16	Al-Rafie Al-Thaniya / (17)	169.27

Source: The researcher's work is based on the results of laboratory analysis of soil samples from the study area that were analyzed in the (Youscience Scientific Laboratory) , November 2025

Map (6) Potassium content (ppm) of the soil in the study area



Source: Researcher based on Table (13) and Arc Map V10.8 software

1- River levee soils:

The overall average concentration of potassium in the levee soils of the rivers in the study area was about 137.79 ppm. The maximum value reached 169.27 ppm, recorded in sample (16), located within sector (17) (Al-Rufai' Al-Thaniya), which is administratively affiliated with the center of Al-Salam sub-district. This sample was classified the medium concentration category.

The minimum value was 73.31 ppm, recorded in sample (3), located within sector (8) (Al-Khams wa Al-Dhala‘), also administratively affiliated with the center of Al-Salam sub-district, and was classified the very low concentration category (Table 6).

The increase in potassium concentration in river levee soils is attributed to high temperatures, which enhance its release by increasing ion exchange processes, thereby raising potassium availability in the soil solution. Conversely, the decrease is mainly due to repeated cultivation without the use of fertilizers by farmers.

River Basin Soil:

The average potassium concentration in the river basin soil of the study area was 152.68 ppm. The highest concentration was recorded in Sample No. 13, located in the Al-Khalifa (11) area, administratively part of the Sayyid Ahmad Al-Rifai sub-district, reaching approximately 176.01 ppm. This sample is classified as having an average concentration.

The lowest concentration, 85.10 ppm, was recorded in Sample No. 10, located in the Khalaf Al-Marqad (11) area, administratively part of the Sayyid Ahmad Al-Rifai sub-district. This sample is classified as having a low concentration (Table 6).

This variation is attributed to differences in soil texture, as soils with a heavy texture tend to contain a higher percentage of potassium compared to soils with a light texture.

Marsh and swamp soils:

The overall mean concentration of potassium in the marsh and swamp soils of the study area was approximately (130.3 ppm). The maximum value reached about (161.7 ppm), recorded in sample (1) located within district (7) (Al-Burhan Al-Awwal), administratively belonging to Al-Salam subdistrict center. This sample falls within the category of moderate concentration. The minimum value was about (90.15 ppm), recorded in sample (15) located within district (4C), administratively belonging to the center of Sayyid Ahmad Al-Rifa’i sub-district. This sample falls within the category of low concentration (Table 6). The high potassium concentrations in marsh and swamp soils are attributed to the fine clayey texture, which is characterized by high water retention, leading to increased potassium content. Additionally, high temperatures enhance evaporation processes, resulting in increased salinity, which in turn promotes the release of potassium.

Conclusions

1. The soil properties in the study area exhibit spatial variation due to natural factors such as river deposits and groundwater conditions .Soil fertility is higher in areas close to rivers and marshes compared to more distant areas.
2. Soil fertility is higher in areas near rivers and marshes compared to more distant areas.
3. Salinity and high groundwater levels negatively impact agricultural land use efficiency.
4. Geographic Information Systems (GIS) have proven effective in analyzing the spatial variation of soil properties.
5. Land use is influenced by both natural and human factors, such as agricultural management, irrigation, and drainage practices.
6. Productivity can be improved by enhancing drainage, reducing salinity, and implementing appropriate fertilization programs.

References

1. Al-‘Awad, K. M. (1987). *Soil fertilization and fertility*. Mosul University Press. (p. 19). (in Arabic).
2. Abdelrahman, H. (2025). *Soil fertility and its quality indicators*. Faculty of Agriculture, Fayoum University. (in Arabic).
3. Al-Mudhaffar, M. S. (n.d.). *Soil geography*. University of Kufa, College of Arts. (in Arabic).
4. Al-Salem, A. I. T. (1989). *Characteristics of soils in Maysan Governorate* (Unpublished master’s thesis). University of Basrah, College of Arts. (in Arabic).
5. Al-Jassim, A. K., & Karim, H. M. (2022). Natural factors affecting agricultural land investment in Al-Maimouna District. *Maysan Research Journal, 18*(35), 537. (in Arabic).
6. Abu Samour, H., & Ghanem, A. (1998). *Introduction to physical geography* (1st ed.). Dar Al-Safaa, Amman. (in Arabic).
7. Al-Akidi, W. K. (1990). *Soil management and land use*. Mosul. (in Arabic).
8. Al-Kaabi, Z. M. A. (2021). *Spatial variation of agricultural soils in Maysan Governorate* (Unpublished master’s thesis). University of Maysan, College of Education. (in Arabic).
9. Al-Qarah Ghuli, D. F. H. (2020). *Geographical analysis of soil characteristics in Al-Shatra District* (Unpublished master’s thesis). University of Basrah, College of Arts. (in Arabic).
10. Al-Saadi, A. F. (2009). *Geography of Iraq*. University of Baghdad Press. (in Arabic).
11. Fanjan, M. K. J. (2021). *Soil characteristics and their spatial relationship with wind erosion in Al-Maimouna District* (Unpublished master’s thesis). University of Maysan, College of Education. (in Arabic).
12. Khan, T. O. (2018). *Management of soil problems*. Springer International Publishing, Switzerland.
13. Nghaimish, Z. R. K. (2023). *Geomorphological forms in Al-Fajr, Kumait, and Al-Maimouna areas using geographic information systems (GIS)* (Unpublished doctoral dissertation). Wasit University, College of Humanities. (in Arabic).