Soil Texture Distribution for East Wasit Province, Iraq

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Abstract. Soil texture affects many physical and chemical properties of soil. Knowledge of soil texture is essential for all water and soil studies. The aim of the research is to draw a map of the spatial distribution of soil texture in the region of eastern Wasit province and know the relationship of texture to the soil's hydrological groups. Laboratory tests were conducted on 25 soil samples. With a depth of 50-75 cm, were selected from locations that represent the study area. According to the unified classification system, The results showed that the soil texture for the samples locations was 40% sand, 16% for both silt loam and sandy loam, 12% for loamy sand, 8% for both sandy clay loam and sandy loam. A soil texture classification map was produced for the study area. The first soil texture map for the area differs significantly from the World Food and Agriculture Organization soil texture classification map. It adopts signed tests of the site. The statistical analysis showed that the per cent sand's standard deviation was 22.65%, silt 19.247%, and 6.416% clay. It turns out that 52% of the soil models from hydrologic group A, 24% from hydrologic group B and 24% from hydrologic group C, Arc GIS software was used to produce maps.

1. Introduction

Physical and chemical properties play a significant role in engineering and agricultural activities. The physical properties are the soil’s texture, the permeability of the soil, and the soil’s moisture. The texture is the structure of the soil and The shapes of the soil and its size. The texture of the soil is sand, silt and clay. The permeability of the soil is the property of the soil whose pores allow the passage of water through it, while the soil moisture is the capacity of the soil to hold water[1]. Therefore, the correct interpretation of soil properties and their correct management is essential not to cause soil degradation [2].

Determining the soil texture is essential for any work-related reason for soil and water. Knowing the percentage of materials that make up the earth helps researchers and specialists in various scientific fields, especially since the study area witnesses torrents and floods during rain[3]. The Soil texture factor is essential to choose suitable sites for artificial groundwater recharge or know the amount of water that can recharge the groundwater. Also, knowledge of the texture helps in selecting appropriate sites for making earth dams and storing floodwater. Soil texture is a critical criterion for selecting, designing and evaluating rainwater harvesting sites [4]. Knowledge of soil texture helps in the economic feasibility studies of many projects.
established within the study area and in selecting the appropriate places. Also, as indicated by previous studies, the soil in the study area is subject to erosion [5]. This is directly related to soil texture and corrosion. Knowledge of soil texture has a direct role in planting [21], selecting suitable crops, estimating sufficient water quantity and irrigation periods for each soil texture [1,6]. Standard deviation can also be used as a further test to indicate the degree of sorting of the soil sample or the particle size distribution [7]. Texture shows the percentage of sand, silt, and clay in the soil, which is a significant component for conducting soil surveys to determine the potential for land use, its boundaries, and its management [8]. Sturdy efforts have been carried out to relate soil properties with soil texture. Soil texture is used to show the proportionate division of the various mineral particles’ sizes in the soil. According to their size, these metal particles are divided. Two global systems control soil classification, the International Society for Soil Science System (ISSS) and the Food and Agriculture Organization of the United States of the U.S. Department of Agriculture and (FAO/USDA) and the size of particles for soil classification [9] as follows table(1).

| Particle | ISSS | FAO/USDA |
|----------|------|----------|
| sand     | 20–2000µm (coarse sand 200–2000 µm) (fine sand 20–200 µm) | 50–2000µm |
| silt     | 2–20µm | 2–µm50 |
| clay     | <2µm | <2µm |

Soils are divided into classes of sand and clay (coarse and fine-grained) that make up the soil. The common laboratory work between the different classification systems is to classify granules using sieving and hydrometer, and there are advanced methods that use lasers. Soil Classification System is essential for hydrology, engineering, geology, and agricultural applications. Soil Texture Triangle is used to classify soil as an integral tool. Classification is done by applying the ratio of each of the soil particles in the textures triangle. Texture representation varies from country to country according to soil topology. The USDA classification method is the most popular classification system. Each place has soil characteristics that differ from the other place, and the depths affect the properties of the soil, as each depth has its characteristics that differ from the other depth, and time affects the soil. Climate, topography, vegetation and parent matter are the main reasons for this difference [10]. Climatic, topographical and hydrological factors influence soil properties [11] in addition to human actions [12] and environmental factors [13]. Soil samples taken from a specific location reflect the physical, chemical and biological characteristics of the place to obtain a map covering the entire area. Soil properties significantly affect hydrological processes and include rain distribution, runoff, groundwater recharge, evaporation, and transpiration. This is done using interpolation techniques to obtain a map covering the soil characteristics in the specified area [14]. The most common method of statistical geographic interpolation is kriging. The soil texture is divided according to the U.S. A Department of Agriculture classification into 12 categories according to the triangle classification, which puts a percentage of sand, silt and clay so that the sum of these percentages is 100 % and neglects the grains of larger gradients that have larger diameters than the grains of sand. However, they have an effective percentage in soil classification. Soil controls rainwater movement into the soil and the surface runoff resulting from rain when rainfall exceeds the soil's ability to infiltrate. Therefore, the soil has an essential and primary influence on the global hydrological cycle. Soils are divided into types of hydrological soils according to surface conditions (filtration rate) and (transfer rate) [15].
soils have little water holding capacity and have a coarse texture. In contrast, soils with a silt texture have a smooth surface and partially retain water, while soils with a clay texture are sticky and have a remarkable ability to hold water because they have small pores. The diameter of the grains is the smallest among the other grains. In general, the more significant the proportion of clay and silt in the soil, the greater its water holding capacity, while particles greater than 2 mm in diameter are considered rock fragments and are not considered when calculating the soil texture. However, they can affect the structure, relationship between soil and water. The process of moving water into soil pores is known as saturated hydraulic conduction.

1.1. *Hydrologic Soil Group*

Soils play an essential role in the global hydrological cycle as they control runoff, transport and infiltration of rainwater and recharge groundwater. Runoff forms when rainfall exceeds the ability of soil to infiltrate [15]. Soil can be classified into hydrological groups based on infiltration rate [16, 22] as follow

Group A consists of a soil texture typically less than 10% clay and more than 90% sand and gravel. The saturated hydraulic conductivity is the porous medium (soil) ability to transport water under saturated conditions. This group is 4% μm / s, and the water flow in this group's soils is low. Infiltration rates are high. Group B - Soil texture for this group usually consists of (10 to 20)% clay and 80% to 90% sand. The water flow in soils of this group is moderately low, and the infiltration rate in soils is moderate. The value of the saturated hydraulic conductivity of this soil is 40 μm per second. Group C - Soils usually consist of about (20 and 40)% of clay and less than 60% of sand. The value of the saturated hydraulic conductivity of this group's soil ranges from 1 to 10 micrometres per second, and the importance of water flow rates in the soils of this group is moderately high and low filtration rates. Group D soils usually consist of 40% clay and less than 60% sand when the soil is thoroughly wet. Water flow in soils of this group is high, and infiltration rates are minimal when thoroughly moist. The hydraulic conductivity of the soil of this group is one μm per second. The soil at the study site consists of rocky weathering in mountainous regions. Floodwaters from Iran and rain in high mountain areas carry sediments to cover low points of their course. These sediments are often silty and loamy that settle in the lower regions, but coarse components remain in the higher area. The aim of the research is to map the spatial distribution of soil texture in the region eastern Wasit governorate and know the relationship of texture to the soil's hydrological groups.

2. Material and methods

2.1. Location of the Study Area

The study area is located in Iraq in Wasit province, the eastern part. It occupies a space of approximately 5043 km². Moreover, it covers the two districts of Badra district, including the districts of (Jassan and Zurbatiyah) and Sheikh Saad district. The study area located between latitudes (32 ° 30 ' - 33 ° 30' north) and longitude (45 ° 30 ' - 47 ° 00' east), with the elevation of the area, ranging from (0 - 966) meters above sea level and decreases. The general slope of the land from the northeast to the southwest and from the eastern boundary towards the centre Figure 1. The terrain varies in the study area, where mountainous areas parallel the borders separating Iraq from Iran. High altitudes are observed, followed by low valleys and places to collect water from the mountain heights and highland areas. The valleys’ soils often formed from the weathering of rocks from the site highlands; you will often find the valley's soil to be a rock girl in the surrounding high places. The cover vegetation of the study area consists mainly in the winter, and spring seasons, which are times of rain you notice the presence of herbaceous
plants covering the region; in the summer, the weather is hot, arid areas, without vegetation, and dominated by drought, where there is no surface water. The only available is groundwater that can be used and harnessed the wealth of this region.

![Location of the Study Area](image)

Figure 1. Location of the Study Area

2.2. Soil Sampling and Analysis
Soil sample sites were chosen to represent all parts of the study area, as shown in Figure 2 generated by Arc Gis software which shows the soil samples' locations and each model's number.

2.3. Fieldwork
A GPS device was used to locate soil samples location. Fig. 3 shows the GPS device and its use in locating samples in the study area. After removing the vegetation layer at a depth of about 50-75 cm, samples were taken, and soil samples were placed in clean bags. The weight of soil samples taken from the site ranged between 10-20 kg, and the number of samples taken from the study area reached 25 samples distributed in a manner representing the entire study area as shown in the site map for samples Figure 2. Soil samples were transferred to the soil laboratory at the College of Engineering, University of Wasit, where the required laboratory tests were performe
2.4. **Laboratory work**

According to ASTM D, 422 - Standard Test Method for Particle-Size Analysis of Soils, sieve analysis of samples was performed. First, the sample was divided by a device for separating the models. The division process was carried out by placing the model inside the separator after breaking the soil aggregate. The sample splits into two parts and leaves the other part; Then, the process is repeated in the specified section until we obtain the appropriate weight for the sieves' size. The selected sample was then dried in an electric oven to obtain a dry sample, then weighed 1500 kg from this sample with a sensitive electronic balance. The sieve analysis process was done by placing the soil sample inside the first sieve with a diameter of 4.75 mm. The standard sieves with a minimum diameter were arranged, and the sieve packet was placed in an electric vibrator. Then, each sieve is weighed with the remaining soil to determine the percentage of the remaining and the transient and determine sand particles' rate in the sample. Then, a soil hydrometer analysis transient from a 200 μm sieve was used, in which the proportion of silt and clay was determined for each model.

2.5. **Soil texture triangle**

After knowing the percentage of sand, silt, and clay that make up the sample by laboratory analysis of sieve and condensate, the triangle of the United States Department of Agriculture was used, which divides the soil into groups according to the proportion of sand, silt and clay, which total 100%, to classify the soil texture, where the results appear in table No. 2. Figure 3 shows the triangle USDA soil texture that divides the soil into 12 texture classes [17].
Soil texture and particle size distribution are critical characteristics of soil because many other soil properties depend on soil texture, so soil texture is essential in soil science and adjacent science[18]. The variation in the soil texture within the study area is due to many factors, including the origin of the parent material and the geological composition of the soil, as well as the difference in the terrain and human activities and the effects of the climate, rain and torrents, water movement and human activities combined lead to the variation of soil texture from one place to another. Soil texture maps were produced spatial texture distribution because knowledge of soil texture is beneficial in soil modelling, planning, and management [19,20]. Table 2 shows the percentage of sand, silt, and clay in each soil sample for which these ratios carried out laboratory tests. Soil tissue was extracted for each sample using the soil texture triangle, where the table shows the soil texture for each model. The highest sand content in the soil samples was 98.68%, while the average sand content for the models was 75.46%, and the lowest sand content was 32.7%, as shown by Figure 4, which was generated with ArcGIS (Arc-map) program and using interpolation kriging tool. The map shows that the proportion of sand in the highland areas is higher than in the low and medium-altitude regions. As shown from the statistical analysis of the percent sand, the standard deviation of 22.65% was less than the mean sand content. This indicates that there is no significant variation between the sand content in the soil sample. The highest silt content in the soil samples was 62%, while the average silt content for the models was 19.1%, and the lowest silt content 1%, as indicated by Figure 5, which was generated with ArcGIS (Arc-map) program and using interpolation kriging tool. The map shows that the percentage of silt in the highland areas is less than in the low and medium-altitude regions. While the highest rate of silt was in the low-lying areas, this, in turn, explains that large proportions of silt in these areas result from torrential water and rain that brought silt from high regions. As is evident from the percent silt's statistical analysis, the
standard deviation of 19.247% indicates little variation between silt content in soil samples.

| NO. | Easting (m) | Northing (m) | %sand | %silt | %clay | Soil texture | Hydrologic Soil Group |
|-----|-------------|--------------|-------|-------|-------|--------------|-----------------------|
| 1   | 577708      | 3627338      | 36    | 62    | 2.0   | Silt Loam    | C                     |
| 2   | 577425      | 3638033      | 54.5  | 44    | 1.5   | Sandy Loam   | B                     |
| 3   | 583001      | 3655898      | 97.9  | 1     | 1.1   | Sand         | A                     |
| 4   | 594831      | 3668925      | 72.5  | 25.8  | 1.7   | Loamy Sand   | A                     |
| 5   | 598131      | 3672208      | 98.68 | 1     | 0.32  | Sand         | A                     |
| 6   | 600280      | 3679999      | 96.75 | 2.25  | 1     | Sand         | A                     |
| 7   | 594253      | 3685677      | 98    | 1     | 1     | Loam         | B                     |
| 8   | 592216      | 3693059      | 97    | 2     | 1     | Sand         | A                     |
| 9   | 587878      | 3690358      | 95    | 2.8   | 2.2   | Sand         | A                     |
| 10  | 607447      | 3675009      | 97    | 2     | 1     | Sand         | A                     |
| 11  | 605058      | 3678716      | 97.2  | 1.5   | 1.3   | Sand         | A                     |
| 12  | 599412      | 3677184      | 98    | 1     | 1     | Sand         | A                     |
| 13  | 586908      | 3673578      | 81    | 14    | 5     | Loam         | B                     |
| 14  | 592562      | 3664489      | 91.22 | 4.04  | 4.74  | Sand         | A                     |
| 15  | 603446      | 3656059      | 77.76 | 20    | 2.24  | Loam         | B                     |
| 16  | 601536      | 3640867      | 97.4  | 1.2   | 1.4   | Sand         | A                     |
| 17  | 615492      | 3637193      | 81    | 14.3  | 4.7   | Loamy Sand   | A                     |
| 18  | 645063      | 3632573      | 80    | 14.6  | 5.4   | Loamy Sand   | A                     |
| 19  | 636406      | 3605904      | 44.8  | 49.5  | 5.7   | Silt Loam    | C                     |
| 20  | 551394      | 3639925      | 32.7  | 52    | 15.3  | Silt Loam    | C                     |
| 21  | 547778      | 3656983      | 60    | 18.8  | 21.2  | sandy clay loam | C   |
| 22  | 557171      | 3661481      | 51.6  | 24.4  | 24    | Sandy Clay Loam | C   |
| 23  | 565532      | 3668413      | 48.2  | 39.5  | 112.3 | Loam         | B                     |
| 24  | 573838      | 3680531      | 60.3  | 27.5  | 12.2  | Sandy Loam   | B                     |
| 25  | 562474      | 3632215      | 42    | 51.3  | 7.7   | Silt Loam    | C                     |
Figure 4. Sand percent

Figure 5. Silt percent
The highest clay content in the soil samples was 24%, while the average clay content for the models was 5.476%, and the lowest clay content of 0.32%, as shown by the map in Figure 6, which was generated with GIS software and with interpolation kriging. It was generated with Arc-GIS (Arc-map) program and using the interpolation kriging tool. The map shows that the percentage of clay in highland areas is significantly less or non-existent than in the low and medium areas. In general, the percentage of clay in the study area was few, while the highest rate of clay was in the central areas, as is evident from the per cent clay's statistical analysis the standard deviation. The amount of 6.416% indicates a difference between the soil samples' clay content.

![Figure 6. Clay percent](image)

Figure (7) shows the graph of the percentage of sand, silt and clay in each sample, as it shows that the percentage of sand is high in most soil samples, while the percentage of clay is low in most samples. We note that the high areas had a sandy texture while the soil texture in the middle regions was sandy loam, while the soil texture in the northern lowlands was sandy clay while the southern lowlands had a silty sand soil texture. The results show the soil texture distribution map for the study area established after conducting laboratory tests and using ArcGIS software. There was a variation in the soil texture, where the highest percentage was 40% for sand texture, 16% for both silt loam and sandy loam, 12% for loamy sand, 8% for both sandy clay loam and sandy loam, and the hydrologic groups were 52% of the soil models from hydrologic group A, 24% from the hydrologic group B and 24% from the hydrologic group C. The Figure 8 shows soil texture for the study area.
A significant difference is observed when comparing the soil map resulting from sampling, laboratory analysis, and Arc-GIS software with the study area's FAO soil map illustrated in Figure 9. This is an excellent scientific addition to the study area. Soil texture information for the area is now accurate and available for use in any study targeting the area, which will provide useful information for decision-makers and professionals.
4. Conclusions
This research presents a map of the spatial distribution of the soil texture for the study area, where the map was made in the Arc G.S. program based on real field data and taken in a way that represents the entire study area, which provided a real classification for the soil texture in the study area. Conclude that the largest proportion of the soil texture is sandy and is mostly concentrated in the high areas, while the proportion of silt increased in the low spots. This may explain the effect of torrents and floods from elevated sites, which carry the smooth texture to the low areas, and the coarse texture remains in the high regions. Most of the soils in the study area have high permeability and significant hydraulic conductivity that cannot hold water.

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