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Soil Properties Study for the Western Side of Kut City, Iraq

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Abstract

Soil properties checks and classification are an important part of any engineering project as they directly affect buildings as well as agriculture and others. The research aims to create an integrated database for soil properties in the study area, which is the western side of the city of Kut, to know its relationship to groundwater in the region. Laboratory tests were conducted for five soil samples from the Bar Drilling sites to monitor the movement of groundwater in the area. Soil samples were taken when drilling and upon reaching the groundwater level, which was approximately 6 meters sieve analysis, hydrometer, specific gravity, and hydraulic conductivity were also conducted, as well as the content of chlorides and sulfates in the soil was calculated. For classifying testure of the soil, the triangle of US agriculture department was utilized, soil can be divided into groups by this triangle based on clay, silt and sand proportion. Results of examination of soil texture showed that the soil in the first was Clay loam and the second point was Silty Clay loam and in the third point, it was sandy clay loam, while in the fourth point it was silty clay loam and it was in the fifth point silt loam As shown in Table 1. The specific gravity was measured in the field, and the lowest value was 2.65 in the third well, while the highest value was 2.70 in the fifth well. The hydraulic conductivity of the five well points was calculated and was close to each other and considered as an average value of hydraulic conductivity equal to 0.013522. The content of chlorides and sulfates in the soil was calculated due to its importance in knowing the chemical properties. The results showed that the value of the chlorides ranged between (0.154 - 1.72) %, while the values of the sulfate content in the soil ranged between (0.930 - 3.11) %.

Keywords: soil, Kut, laboratory testing, Hydraulic Conductivity, particle size distribution, sieve Analysis.

الخلاصة: تعتبر عمليات فحص وتصنيف خصائص التربة جزءًا مهمًا من أي مشروع هندسي لأنها تؤثر بشكل مباشر على المباني وكذلك الزراعة وغيرها. إن معرفة الخصائص الفيزيائية والكيميائية للتربة أمر مهم للغاية لدراسة التربة والمياه. يهدف البحث إلى إنشاء قاعدة بيانات متكاملة لخصائص التربة في منطقة الدراسة ، وهي الجهة الغربية لمدينة الكوت ، لمعرفة علاقتها بالمياه الجوفية في المنطقة. تم إجراء الاختبارات المعملية لخمسة عينات من التربة من مواقع حفر ابار المراقبة لرصد حركة المياه الجوفية في المنطقة. تم أخذ عينات التربة عند الحفر وعند الوصول إلى مستوى المياه الجوفية والذي كان يقارب ٦ أمتار. تحليل الغربال ، كما تم إجراء مقياس كثافة السوائل والجاذبية النوعية والتوصيل الهيدروليكي ، وكذلك تم حساب محتوى الكلوريدات والكبريتات في التربة. لتصنيف شهادة التربة ، تم استخدام مثلث وزارة الزراعة الأمريكية ، ويمكن تقسيم التربة إلى مجموعات بواسطة هذا المثلث على أساس نسبة الطين والطمي والرمل. أظهرت نتائج فحص قوام التربة أن التربة في الأولى كانت تربة طينية والنقطة الثانية كانت طمى طيني وفي النقطة الثالثة كانت تربة طينية رملية ، بينما في النقطة الرابعة كانت طمى طيني وكانت في النقطة الخامسة طمية كما هو موضح في الجدول رقم ١. تم قياس الثقل النوعي في الحقل ، وكانت أقل قيمة ٢,٦٥ في البئر الثالثة ، بينما كانت أعلى قيمة ٢,٧٠ في البئر الخامس. تم حساب الموصلية الهيدروليكية لنقاط الآبار الخمس وكانت قريبة من بعضها البعض واعتبرت متوسط قيمة التوصيل الهيدروليكي يساوي ٠,٠١٣٥٢٢. تم حساب محتوى الكلوريدات والكبريتات في التربة لأهميتها في معرفة الخواص الكيميائية. أظهرت النتائج أن قيمة الكلوريدات تراوحت بين (٠,١٥٤ - ١,٧٢)٪ بينما تراوحت قيم محتوى الكبريتات في التربة بين (٠,٩٣٠ - ٣,١١)٪.

1. INTRODUCTION

Laboratory tests of soil were conducted to identify some of its physical and chemical properties and thus to classify it and know its structural formation and its ability to transport groundwater. Soil samples were taken at the drilling points upon reaching the groundwater level. Soil physical properties include soil texture and specific gravity and soil permeability Texture is the structure of the soil Permeability is the property of soil that expresses the pores in the soil to allow water to pass through them [١]. Therefore, it is crucial to correctly assess soil qualities and manage them to prevent soil degradation. [2]. Soil tests (specific density, granular gradation, hydrometer test, chloride content, sulfate content in the soil) were carried out. Any reason involving soil and water at work requires determining the soil texture. Researchers and experts in a variety of scientific domains benefit from knowing the proportion of elements that make up the earth [3] Knowing the amount of water that can replenish the groundwater or selecting suitable locations for artificial groundwater recharge depends on the soil texture component. Additionally, understanding the texture aids in choosing the best locations for building earth dams and storing floodwater.

A crucial consideration for choosing, planning, and assessing rainwater harvesting sites is the texture of the soil. [4] A key factor in conducting soil surveys to ascertain the potential for land

Table1. Numbers type of soil in the study area

Sample no.	Type of soil
1	Clay loam
2	Silty Clay loam
3	Sandy clay loam
4	Silty clay loam
5	Silt Loam

use, its limits, and its management is texture, which reveals the amount of clay, silt and sand in the soil. [5] The grades of coarse- and fine-grained sand and clay that makeup soil are used to categorize them. Granules are classified in laboratories using sieving and hydrometers for the majority of classification systems, while there are more sophisticated techniques that employ lasers. Applications in hydrology, engineering, geology, and agriculture all need the use of the soil classification system. The Soil Texture Triangle is a crucial tool for classifying soil. The ratio of each soil particle is applied during classification using the textures triangle. Depending on the morphology of the soil, texture representation varies from country to country. The most widely used classification scheme is that used by the USDA. Each location has unique soil qualities, and soil attributes are influenced by depth as well. [6] Soil qualities are influenced by climatic, topographical, and hydrological conditions. [7] To give a picture of the soil in the entire area, soil samples taken from a particular place reflect the physical, chemical, and biological characteristics of the area. The properties of the soil greatly affect the hydrological processes in the region, which are represented by the distribution of rain, runoff, groundwater recharge, evaporation, and transpiration. [8]

2. METHOD AND MATERIAL

2.1. Study area location

The area of investigation lies on the western side of kut city in Wasit Province Iraq. Between the Tigris River and the Al-Gharraf river, it extends to the administrative borders of the city of Al-Kut .It covers an area of about 122 square kilometers Between 32° 30′ 0″ N to 32° 26′ 30″ N latitude and 45° 48′ 0″ E to 45° 52′ 0″E longitude, as shown in Figure 1. Where shows the location of the observation points. Al Kut is a city in Iraq and the capital of WASSIT province is located in the Iraqi CITY of KUT, 180 kilometers southeast of the capital, Baghdad, the location of Kut lies on a significant position with respect to Tigris River, which surrounds it from east, south and west. North of the city, upstream its barrage, two rivers are diverted from Tigris, they are Al-Gharaf branch and Al-Dujaili branch. The area of the governorate is 17,153 square kilometers. KUT city lies 238 km south of Diyala, 272 km east of Babylon, lies 100 km west of Iran, 353 km northeast of Dewania, 187 km north of Nasiriya, and 191 km northwest of Amara. It has hot and dry summer is cold and wet winters. In the investigated area, the climate is semi arid, in which summer are long, very hot and dry, winter is cold and wet and relatively wet, and springs is shorter than usual and mild. Great temperature differences can be recorded between day hours and night hours and also between summer and winter. Depending on the carried sediments of Tigris, soils of Wasit was formed [٩]. In Wasit, the main water source is Tigirs, but in Kut city, the main stream of Tigris as well as Al-Garraf brach are the sources of water. From the north toward the south of Wasit, Tigris flows. For the aim of agriculture irrigation and water control, several hydraulic projects have been built in Wasit. [10]. Area of investigation was classified into to sets, a residential area, and an agricultural area, and it is considered fertile land because it is in the middle of the Tigris River and its branches in the city of Kut. Its land is almost flat.

Figure 1 The Study Area Location and sampling points

2.2. Soil Sampling

After determining the points in the study area, which were determined to cover the entire area, and taking into account the location of the Tigris and Gharraf rivers. Soil samples were taken from five points after drilling wells to monitor the groundwater in the area. Soil samples were taken upon reaching the groundwater level

2.3. Field Work

A device of GPS was depended for specifying the position of soil specimens after drilling to a depth of approximately 6 meters when reaching the aquifer. Specimens were gathered and located in special bags and sealed tightly. Five samples were taken from five drilling sites in the study area distributed in a way that represents the area. Then, the collecred specimens were taken to laboratory of soil at Civil engineering department /Wasit University to perform the necessary experiments. A site-specific gravity test was conducted at the sampling points. Table 2. shows the coordinates of the sampling points. The specific gravity test was carried out according to ASTM D 854_14 As shown in Table 3.

Table 2. The coordinates of the sampling points

Wall no.	longitude	Latitude
W1	45° 49′ 27.5″	32° 29′ 09.7″
W2	45° 49′ 39.4″	32° 28′ 52.5″
W3	45° 49′ 48.8″	32° 28′ 40.2″
W4	45° 48′ 50.5″	32° 29′ 08.4″
W5	45° 48′ 51.4″	32° 26′ 52.8″

2.4 laboratory work

Laboratory tests were conducted for soil samples, which represented sieve analysis, hydrometer, hydraulic conductivity, and calculation of the concentration of chlorides and sulfates in soil samples. The tests were carried out according to the standard specifications shown in Table 3. and as follows:

- **Soil granular distribution Test**

Understanding soil attributes begin with a basic understanding of what may be observed, such as particle size distribution. A list of values or a mathematical function describes the particle size distribution. that specifies the relative quantities of particles present, grouped by size. Particle Grain size distribution is another name for size distribution. [11]. The porosity, permeability, consolidation, shear, and volume change behavior of soil are all affected by particle size distribution. After knowing the proportions of sand silt and clay, the soil will be classified according to the resulting proportions The United States Department of Agriculture's triangle was utilized, as shown in

Table 3. Laboratory testing standards.

Laboratory testing to distributed Samples (DS)	Standards for laboratory testing
Specific Gravity (GS)	ASTM D 854-14
Grain Size Distribution and Hydrometer Analysis	ASTM D422
hydraulic conductivity	ASTM D 2434.
Soil chloride content (CL)	(BS1377. part.3)
Soil sulfite content (SO3 -2)	(BS1377. part.3)

Figure 2. to split the soil into groups based on the proportions of sand, silt, and clay. To specify the distribution of particle sizes less than 0.075 mm, the hydrometer analysis method is employed (No. 200 sieve). The fine (which passes through sieve No. 200) and course (which does not pass-through sieve No. 200) fractions can be used to classify soil.

- **Soil Hydraulic Conductivity Test**

In soil mechanics, the investigation of water flows throughout porous soil layers is crucial. It can be considered necessary required to estimate quantity of subsurface percolation due to varied hydraulic circumstances, to conduct research issues with water pumping for underground construction and for producing stability evaluations of seepage-prone earth dams and earth-retaining structures One of the most important physical characteristics of a soil that influences the pace of seepage. Hydraulic conductivity, often known as the coefficient of permeability, runs through it. Soil hydraulic conductivity is governed by a range of factors: The viscosity of the fluid, the pore size distribution, the grain size distribution, the void ratio, the roughness of mineral particles, and the degree of soil saturation are all factors to consider. The ionic concentration and the thickness of layers of water adhered to the clay particles are two other key parameters that determine the permeability of clays [12].

- **Soil chloride content (CL)**

Chlorides are present in the soil in the form of different salts that are soluble in water. Chlorides are abundant in dry soil, and their concentration in the soil varies according to the quality of the soil and its degree of salinity. For each study of soil and water, knowledge of the physical and chemical properties of soil is of special importance.

- **Soil sulfite content (SO3 -2)**

Sulfates are found in most lands and groundwater in different quantities and are deposited in the soil in significant quantities, and their impact on crops and reclamation processes varies according to the different compositions. Calculation of the water-soluble sulfate ions content in the soil includes the formation of a barium sulfate precipitate, and the results were reported as sulfite content in the percentage of soil weight.

3. RESULTS AND DISCUSSION

Because many other soil qualities depend on soil texture, soil texture is crucial in both soil science and related fields of study. Another important aspect of soil is particle size distribution [13]. Tables 4,5,6,7,8. show the result of the sieve Analysis Test for the five samples

Table 4. The Sieve analysis for the soils of the study area (sample no. 1)

Sieve NO.	Sieve opening (mm)	Mass retained (g)	Percent of mass retained	Cumulative percent retained	Percent finer
4	4.75	35.60	7.14	7.14	92.86
10	2.00	45.48	9.12	16.26	83.74
20	1.85	33.39	6.70	22.96	77.04
40	0.425	20.88	4.19	27.15	72.85
60	0.250	87.82	17.62	44.77	59.28
120	0.125	170.80	34.28	79.05	23.95
200	0.075	25.93	5.20	84.25	8.7
Pan	--------	78.30	15.71		
total		498.20			

Table 5. The Sieve analysis for the soils of the study area (sample no. 2)

Sieve NO.	Sieve size (mm)	Retained mass (g)	Percentage of retained mass	Percentage of cumulative retained mass	Percentage of finer
4	4.75	32.30	6.47	6.47	93.53
10	2.00	42.48	8.51	14.98	85.02
20	1.85	30.40	6.09	21.07	78.93
40	0.425	22.80	4.56	25.63	76.37
60	0.250	88.82	17.80	43.43	56.57
120	0.125	175.50	35.17	78.6	26.08
200	0.075	27.55	5.52	84.12	9.2
Pan	--------	79.10	15.85		
total		498.95			

Table 6. The Sieve analysis for the soils of the study area (sample no. 3)

Sieve NO.	Sieve opening (mm)	Mass retained (g)	Percent of mass retained	Cumulative percent retained	Percent finer
4	4.75	36.25	7.30	7.30	92.7
10	2.00	40.40	8.14	15.44	84.56
20	1.85	33.35	6.68	22.12	77.88
40	0.425	30.10	6.06	28.18	71.82
60	0.250	80.70	16.27	44.45	55.55
120	0.125	155.50	31.35	75.8	24.2
200	0.075	29.50	5.94	81.74	18.26
Pan	--------	90.10	18.16		
total		495.9			

Table 7. The Sieve analysis for the soils of the study area (sample no. 4)

Sieve NO.	Sieve opening (mm)	Mass retained (g)	Percent of mass retained	Cumulative percent retained	Percent finer
4	4.75	33.60	6.75	6.75	93.25
10	2.00	48.40	9.73	16.48	83.52
20	1.85	35.40	7.12	23.6	76.4
40	0.425	23.80	4.78	28.38	71.62
60	0.250	89.70	18.04	46.42	53.58
120	0.125	173.40	34.88	81.3	18.7
200	0.075	30.70	6.17	87.47	12.53
Pan	--------	62.10	12.49		
total		497.10			

Table 8. The Sieve analysis for the soils of the study area (sample no. 5)

Sieve NO.	Sieve opening (mm)	Mass retained (g)	Percent of mass retained	Cumulative percent retained	Percent finer
4	4.75	37.30	7.50	7.50	92.5
10	2.00	32.30	6.49	13.99	86.01
20	1.85	35.20	7.07	21.06	78.94
40	0.425	26.70	5.37	26.43	76.57
60	0.250	85.55	17.20	43.63	58.24
120	0.125	162.40	32.66	76.29	27.71
200	0.075	27.55	5.54	81.83	9.3
Pan	--------	90.20	18.14		
total		497.20			

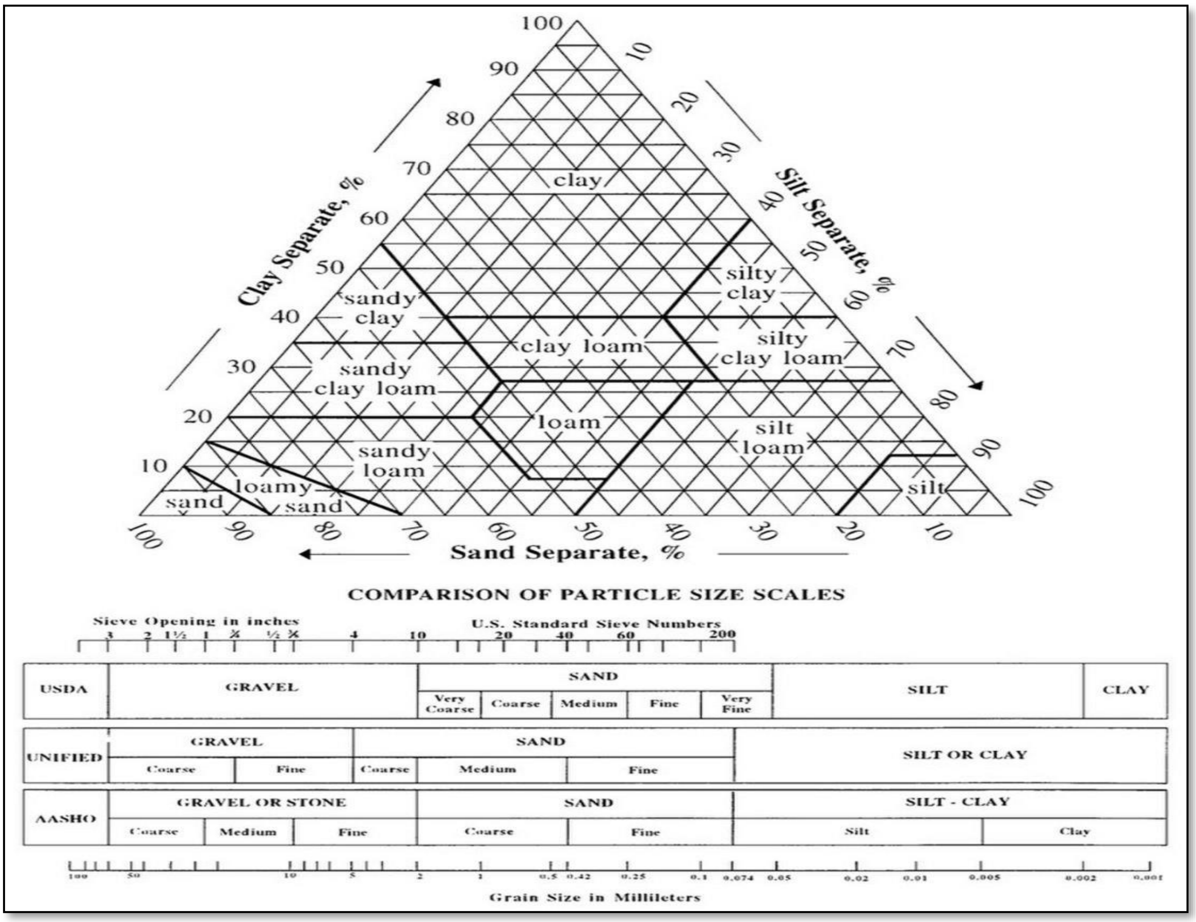

Figure 2 Soil texture triangle [12].

According to the carried out experimental tests, Clay, silt and sand percentage for each specimen of soil is shown in Table 9. The highest percentage of clay was 36% in points (1,4) and the lowest value was 22% in the fifth point, and the average percentage of clay for all samples was 30.8% ,The highest percentage of silt was 62% in the fourth point and the lowest value was 27% in the third point, and the average percentage of silt for all samples was 48% The highest sand percentage reached 45% in the third point and the lowest value was 2% in the fourth point, and the average sand percentage for all samples was 21.1% From the above results, it is clear that the largest component in the study area is silt and clay, and the lowest component is sand.

Table 9. The particle size distribution ,hydrometer analysis

Sample no.	Depth (m)	Clay%	Silt%	Sand%	Gravel%
w1	6	36	42	22	0
w2	6	32	48	20	0
w3	6	28	27	45	0
w4	6	36	62	2	0
w5	6	22	61	17	0

The specific gravity values were similar for all samples, with the lowest value being 2.65 and the highest value being 2.70, and the average specific gravity for all samples was 2.68.
Also, the hydraulic conductivity values of the samples were close, where the lowest value was 0.01344 and the highest value was 0.01365, and the average value of the hydraulic conductivity for all samples was 0.0135 Table 10. shows the specific gravity and hydraulic conductivity values of the samples

Table 10. The result of specific gravity and hydraulic conductivity for the study area

Sample no.	Specific gravity (GS)	Hydraulic conductivity (K)
w1	2.69	0.01352
w2	2.69	0.01352
w3	2.65	0.01365
w4	2.68	0.01348
w5	2.70	0.01344

The chloride concentration values in the samples ranged between (0.154 -1.72) %, and the average concentration of chlorides for all samples was 0.98%.
The values of sulfate concentration ranged between (0.93-3.11) %, and the average sulfate for all samples was 2%. Table 11. shows the concentrations of chlorides and sulfates in the samples.

Table 11. The result of the concentrations of chlorides and sulfates in the samples.

Sample no.	chloride content (CL)%	sulfite content (SO_3 -2)%
w1	1.72	3.11
w2	1.63	2.91
w3	0.154	1.087
w4	1.18	2.09
w5	0.245	0.930

4. CONCLUSIONS

The current study displays the soil texture classification in the western side of Kut city after identifying points from which soil samples were taken to represent the entire region, which provided a true classification of soil texture in the study area. The results showed that the proportion of the largest soil texture is silt and clay. and as a result of this soil texture, it is less permeable and has a high density thus it can retain water. This research provided a complete base for soil evidence in area of investigation study, which can benefit researchers in the future in this area, as well as reduce costs when blinding the infrastructure in the area.

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