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Characterization and Comparative Analysis of Arid and Fertile Soils from Al-Najaf: Understanding Soil Composition and Properties

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Abstract: *Characteristics of arid non-arid soils from Najaf were studied to find out the main issues need to be solved in order to achieve sustainable management practices of agricultural and environment. The collected soil samples were prepared and analysed in accordance with the standards either presented by the Soil Science Society of America (SSSA) or the Food and Agriculture Organization (FAO) methods. The soil properties namely, texture, saturated hydraulic conductivity (Ks), electrical conductivity (EC), pH, organic matter content (SOM), soil respiration, cation exchange capacity (CEC) and total nitrogen and total phosphorus were examined. The findings reveal that the arid and non-arid soils behaved as poorly structured by sand particles. The mean Ks values of arid soils have a lower value (14.9 cm/h) than non-arid soil (21.4 cm/h), which may lead to an increased drainage in arid climate. The soil respiration rates (both soil type) were taken and found to be under the limit for detection, suggesting low carbon dioxide release by microorganisms. Furthermore, soil pH values are favorable for nutrient absorption by plants. The salinity in arid soils, (EC 28 dS/m^2) is far more the non-arid soil (0.6 dS/m^2) which is one of the major challenges of arid soil. Despite arid soil looking low on soil organic matter (SOM) values (0.65%), similar values (1.5%) in the non-arid soil are another indicator on the need for the soils to be fertility enhanced for effective plant growth. Furthermore, CEC values of moderate to high levels (5.98 meq. /100g soil) in arid and (6.33 meq. /100g soil) in non-arid. Nitrogen retention ability which (TN) ranges within the accepted levels (0.14%) in soils in both types, shall not be a problem; however, TP levels is ranked rather low in arid soils which is significant and urgent for the management of soil fertility. These results, as such, reinforce the fact that sustainable management policies backed with more awareness are the key factors that need to be applied in arid localities with a view to elevating the status of the soil health present there and prolonging the quest for the soil productivity.*

Keywords: *Soil Properties; Soil EC, Ks, LOI; Soil respiration; sieve analysis; Excessive Drainage; Arid climates*

I. Introduction

The intricate combination of minerals, organic material, water, and air that is the World's top layer is known as soil. These components consolidate well to influence different soil types and their functions. Weathered down rocks and raw minerals make up the inorganic part of soil. They affect the structure, texture, and the nutrient availability in the soil. Decomposed plant and animal waste result in organic matter, fundamental for soil microbial turnover, water retention, and fertility. It is possible for water and air to enter the soil's pores. This is significant for functions like microbial ingestion, enhanced nutrient transportation, and root respiration [1].

Gaining an understanding of the interactions between biological, climatic, and geological elements are necessary to understand soil structure. Local factors, such as parent material and weathering cycles, have an

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impact on the soil mineral content. The rates of soil formation, organic matter decomposition, and soil moisture content become affected by climate. The activity of plants and other animals affects the creation of soil structure, the cycling of nutrients, and the organic matter generation [2].

The study to understand the samples of barren and fertile soil is composed of the most parts of the multidisciplinary activities from the agricultural viewpoint, the knowledge of these soils is valuable because they influence the factors such as nutrient retention, water holding capacity, and drainage signals altogether affecting the crop production, so that the agricultural practices can be developed accordingly to each soil type. On an environmental end, they can be used to measure soil health, ecosystem functioning and biodiversity conservation, which are all important for climate change adaptation, carbon sequestration and environmental degradation mitigation. We are not only responsible for its management but also for understanding the soil's constitution and properties. This information is crucial in designing land use plans, sustainable development practices, and natural resource management and therefore we should focus on conservation, prevention of erosion, and keeping soil fertility and productivity intact. [3].

The soil of the Al-Najaf area of Iraq has many indicators that the current landscape of the geographic environment determines it to a high extent. Geographically, Al-Najaf is centrally located in southern Iraq, a country known for its dry to semi-dry climate. This area consists of the Mesopotamia plain and this area is referred to as the birthplace of civilization. Being built on the banks of Euphrates and Tigris rivers which have been the basis for agriculture, economics and culture in the area, it makes this topography remarkable. The climate is moderately cold winters and hot dry summers with considerable seasonal dissimilarities in precipitation. These climate conditions have a role in processes of soil formation that in turn, result in various types and characteristics of soil, which are dependent on the natural features of the area [4]. Aridisols which cover a relatively large area (62.2%) among the soils in Al-Najaf are key for food stability, stressing the importance of knowing the features of this type [5].

The goal is to investigate the features of arid soils and compare them to those of non-arid soils to better understand the main challenges linked to arid soil and their impact on development, environmental sustainability, and agriculture. Thus, the objectives include the collection of soil samples for the purpose from three arid areas and three non-arid areas; the analysis of the soil samples based on standard methods such as the FAO or SSSA methods involving a variety of parameters, including but not limited to texture, pH, organic matter content , cation exchange capacity , saturated hydraulic conductivity , electrical conductivity , soil respiration, and total nitrogen and phosphorus ; the comparison of the soil characteristics between non-arid and arid samples.

This study is a look at the properties of arid soils and the differences between soils with arid and non-arid characteristics in order to get the ideas of the complexity of arid soil conditions and their impact on agricultural, resource preservation, and development. The purpose of the investigation is the collection and the analysis of soil of corners of three very arid areas with the indifferent corner of the same arid regions (not dry lands). A wide range of parameters, including texture, Ks, EC, pH, SOM, soil respiration, CEC, N and P levels in solution, are measured using standard techniques, such as FAO or SSSA methods.

II. Experimental procedure

Soil samples were collected from three sites in the northwest of Najaf Governorate as indicated on the map, in Figure 2 with circles marking the sample locations. This research utilized a variety of techniques recommended by either the Soil Science Society of America (SSSA) or the Food and Agriculture Organization (FAO) to thoroughly analyze soil properties. Soil texture was determined through analysis separating soil particles based on their size fractions. The falling head method was used to measure conductivity providing insights into water movement in soils. PH levels were measured to assess acidity or alkalinity crucial for practices. Electrical conductivity tests were conducted to evaluate soil salinity and nutrient levels. Loss, on ignition was employed to estimate matter content by burning off materials. Soil respiration was quantified through titration to measure carbon dioxide emissions from activities. The cation exchange capacity was assessed to understand the soils ability to retain cations. The researchers used the Kjeldahl method to measure the nitrogen levels in the soil [13, 14]. They analyzed the soils total phosphorus content using colorimetric methods at a 420 nm wavelength [15].

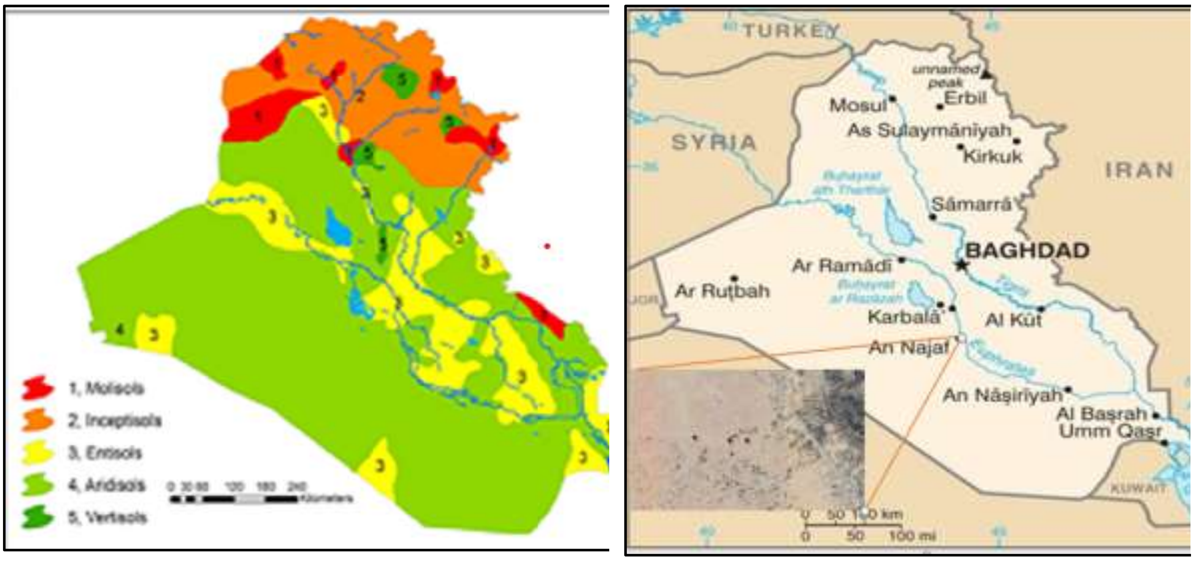

Figure 1: The map on the right, shows the locations of the samples, indicated by red circles in the enlarged section. The map on the left depicts Iraqi soils map

III. Results and discussion:

Soil texture:

The results from soil particle size distribution analysis here 94.9 % for reference. soil samples set for 93.7% moisture content against Arid soil samples sand content brought glaringly to the attention of the predominance of coarse-textured properties, see table 1. This affords the US not only with the drainage and aeration concepts, but also raises the water and nutrient retention problems and erosion issues. Plants in sandy soils may be unable to hold onto the right amount of nutrients as the very low cation exchange capacity (CEC) of these soils does not provide suitable environments for nutrition supply. Sandy soils have low nutrient capacity and excessively loose structure, thus the nutrients are washed out and not available for use by the plants. [16] Stands also have Cation Exchange Capacities (CEC) that enable the soil to hold the critical nutrients that are vital for crop growth. [17] There will be research shown that it can be improved the water and nutrient retention if the particular soil additives are applied to sandy soils. As an example, the utilization of vermiculite and bentonite as a soil improviser has been proven to enhance soil moisture retention [18]. Besides, the usage of lime- or silicon-contented material has proved effectiveness in reducing the overall loss of nutrients within the soil and increasing the longevity of the plants grown in the sandy soils [19]

The analysis of and the improvement in the CEC in the sandy soils is the key to making the nutrients more available and promoting healthier plant growth in these incessant conditions. Consider the consequences of this soils composition is really necessary for us to be fully informed when we are talking about agricultural, land management or environmental conservation issues. New researches and adaptive management practices are needed to mitigate the complications and peculiarities endemic to the soils that are sandy and highly sandy.

Table 1: Mean of (Sand)% and (Clay+ Silt)% values for Ref. and Arid soil samples with Standard Deviation (SD) values

Mean of (Sand)% for Ref. soil samples	**94.917**
SD of (Sand%) for Reference soil samples	**0.928**
Mean of (Sand)% for Arid Soil sample	**93.783**
SD of (Sand%) for Arid Soil samples	**2.340**
Mean of (Clay+ Silt)% for Ref. soil samples	**5.083**

SD of (Clay+ Silt) for Reference soil samples	**0.928**
Mean of (Clay+ Silt)% for Arid Soil sample	**6.217**
SD of (Clay+ Silt) for Arid Soil samples	**2.340**

Saturated hydraulic conductivity (Ks)
Assessing soil texture, structure and the hydraulic properties relate to the soils ability to supports plants growth and in planning suitable management practices. Non-arid soil samples appear to have a considerably higher mean saturated hydraulic conductivity (Ks) than those in arid region in the table 2 (21.46cm/h vs 14.9cm/h), indicated that any plant growth related problems could at least partly be explained here. A targeted drainage is the main benefit for such high values, which nevertheless might be very destructive if they exceed 100 cm/h (excessive drainage, nutrient loss and decreased moisture capacity in sand or unstructured soils). Therefore, in a way, hydraulic conductivity works towards drainage (durable in optimism); in excess, it interferes with the balancing act of soil moisture and plant growth [20].

Table 2: The mean saturated hydraulic conductivity (Ks) for arid and non-arid (Ref.) soils

Non arid (Ref.) soil sample		**Arid soil samples**	
Mean (cm/h)	21.460	Mean (cm/h)	14.900
SD	2.571	SD	3.486

Soil pH and EC
Soil pH value of 5.85 as observed in this study reveals slightly acidic soil conditions. This finding is compatible with previous studies noting environmental factors such as parent material, vegetation and anthropogenic intervention influence the soil pH. The pH of 5.85 is within the optimum range not just for certain crops but also for acquiring enough nutrients by plants without any issues. Yet, up of course, should be to take into account the precise needs of a specific plant species under consideration, because some plants may prefer slightly varied pH conditions. Furthermore, the soil pH is an indispensable component of microbe's activity and nutrient cyclic process which affect soil fertility and finally the whole ecosystem health. As usual there is a pH level which is within the acceptable range, various activities should be undertaken to identify the contributing factors to soil acidity especially if agricultural productivity or ecosystem functions will be affected. Amendments to soil management techniques, like liming or allowing the content of organic matter to increase, might be needed to get the appropriate land use land pH.
Hypersaline soils are soils that contain very high salinity levels, so much so that their electrical conductivity values are higher than 16 dS/m (Tan, 2010). These soils are very much degraded and they may be extensively leached and necessary soil amendments to desalinate and restore fertility. The high level of dissolved salts in the arid soil is confirmed by the electrical conductivity of 28 decisions/m. However, most non-arid soil samples presented the lowest electrical conductivity values as evidenced in table 3,

Table 3: Values and the Mean of Soil pH and EC for arid and non-arid Soils samples

Sample label	**EC (mS/cm)**	**pH**	**Sample label**	**EC (mS/cm)**	**pH**
Ref. 1	605	6.2	Arid. 1	28250	6.2
Ref. 2	553	5.9	Arid. 2	31600	6.9
Ref. 3	522	5.5	Arid. 3	27950	NA
Mean	560	5.85	Mean	28100	6.2
SD	56.569	0.495	SD	2474.874	0.495

Estimate soil organic matter (SOM)% as loss-on-ignition (LOI) %

The types of soils that are placed into the Low Organic Matter Soils category have an organic matter content less than 2 %. They are frequently found in scrublands and heavily disturbed environments which are common in deserts. It can be seen that the mean of organic matter content in reef zone is. soil samples higher than the average organic leaflet matter content in Arid lands soil samples table 4. A very low percentage of soil organic matter content of 0.65% for arid soil and 1.5% for non-arid soil found in this study is a good indicator of this fact that much of the organic content of the soil is missing. Organic material is vital in maintaining the health and fertility of soil by improving soil structure, water capture and release, nutrient availability, and microbial activity. Accordingly, 0.65% and 1.5% is the common range in low organic matter soils; however, organic matter concentrations play a significant role in how the soil functions and the natural ecosystems can operate. More organic matter in the soil is usually related to great soil fertility and productivity as the organic matter contains nutrients that are essential and provides a habitat for helpful soil animals. On the other hand, though soils with less organic matter will still hold water rather well, they will be more prone to erosion, since they will have a decreased ability to cycle nutrients. Comprehending how soil organic matter is affected is vital in the development of sustainable territorial management decisions. Examination of the organic matter content in soils over time can help to determine the steps to be taken by policymakers to conserve soil, crop farmers, and climate change mitigation strategies. The key behind further studies into those factors governing the dynamics of soil organic matter is the fact that they include land use practices, climate conditions, and soil management strategies, therefore the most pertinent is to use these elements to optimize soil health in the framework of both agroecosystems and natural environments.

Table 4: Values and the Mean of organic matter percentage for arid and non-arid Soils samples

Sample label	**LOI%**	**Sample label**	**LOI%**
Ref. 1	1.52%	Arid 1	NA
Ref. 2	1.33%	Arid 2	0.66%
Ref. 3	1.51%	Arid 3	0.86%
Ref. 4	1.64%	Arid 4	0.43%
Mean	1.50%	Mean	0.65%
SD	0.001	SD	0.002

Soil Respiration

It is to state that the values of soil respiration rates were on the lower side of detector limit when the method used to estimate CO_2 output from microbial activity in both soils provided an analytical volume. A detection limit of measurement technology is a minimum measurable value to which the precision at which a device detects is the lowest.

Soil cation exchange capacity (CEC)

The measured CEC value of 6 reveals the soil cable to hold and exchange positively charged ions, or cations. CEC among the privileged positions of soil fertility and nutrient management, it determines the degree of retaining and availability of nutrients for plants uptake. The CEC value of 5.98 and 6.33 shows strong to very good capacity for cation exchange which results in greater ability of retaining essential nutrients such as calcium, magnesium, potassium, and ammonium (22). These soils with elevated CEC content are normally strong and fertile thus making them favorable for vegetation growth. When comprehending the role of the CEC soil value we are in a position to take the right fertilizer application, amendment as well as crop selection to ensure the https://writingins.com/product/do-my-assignment/ optimization of agricultural productivity while maintaining low environmental effects. Even though the salinity is crucial, but another study, and more consideration on texture, pH, and level of organic matter content must be done for a comprehensive soil management strategy.

Table 5: Mean of cation exchange capacity for arid and non-arid Soils samples

Ref.	CEC meq. /100 soil	Arid	CEC meq. /100 soil
Mean	6.333	Mean	5.985
SD	0.270	SD	0.952

Total Nitrogen

The soil total nitrogen of 0.14% has the meaning of soil nitrogen fertility, which is a critical parameter that affects the growth and the productivity of the plants. Nitrogen is an important nutrient which is necessary in plants for various biochemical processes, such as photosynthesis, protein synthesis and enzyme activity. Thus, the soil nitrogen level is highly important for the best use of fertilizers and the overall plant health. In sandy soils, nitrogen levels that are lower than 0.1 % are typically viewed as low [24]. However, such classification may differ in individual agricultural or ecological contexts. TN content of 0.14% is a typical range of many soils though it may differ depending on type of soil, management practices and environment.

If soil has enough nitrogen, it may be able to support maximum crop productivity, while leading to sustainable and robust agricultural production. But whetting of crops in nitrogen starvation also requires supplementation of nitrogen into soil through fertilization in order to fulfill their nutritional needs. Additionally, the high nitrogen levels cause two environmental problems, the first is groundwater contamination, and the other one is greenhouse gas emissions. Therefore, the control of soil nitrogen becomes a necessity on bid of good nutrient use and environmental performance in agricultural systems.

Table 6: Values and the Mean of percentage of total nitrogen content for arid and non-arid Soils samples

Sample label	Total N(%)	Sample label	Total N(%)
Arid Soil sample 1	0.148	Ref. 1	0.143
Arid Soil sample 2	0.154	Ref. 2	0.145
Arid Soil sample 3	0.141	Ref. 3	0.142
Mean	0.148	Mean	0.143
SD	0.007	SD	0.002

Total Phosphorus

Phosphorus is a critical nutrient in all growth phase of a plant as it takes part in cell division, respiration, photosynthesis, and flower formation, among other processes. A low potential of 0.003% total phosphorus shows up in the arid soil, meaning that the soil is generally a poor phosphorus resource. Accessibility of phosphorous for soils being an issue due to low solubility and especially moisture following the high fixation capacity of soil minerals. Thus, the soil with overall low total phosphorus values may receive phosphorus fertilizer to match the plant/crop requirements [25]. Fertilization strategies should be undertaken with great care, taking into account soil phosphorus level, the crops requirement and environmental issues in order to provide better plant growth and reduce the risk of having excessive nutrients to the environment. Furthermore, in terms of soil management some practices, such as crop rotation, organic matter incorporation, and concentration tillage, can lead to greater availability and cycling of phosphorus in the soil in the run. Soil contained total phosphorus at 0.045%, according to Ref. soil test results show that the soil phosphorus is at a medium level and see table 2. The 3.3 - 9.5 mmol/kg level indicates that the soil may be a possible source of phosphorus for plant development and the amount required is depended on the type of plant cultivated. On the other hand, careful phosphorus control is a key resolution, since high phosphorus level can lead to water body eutrophication. Attentive crop husbandry including balanced fertilization and nutrient management must be highly regarded in accordance with the objective of nutrient accessibility for crop uptake as well as minimization of environmental pollution. Apart from these, the options like soil testing, crop rotation, and organic matter applications can give control of suitable level of phosphorus for agricultural sustainability and ecosystem health [26].

Table 7: Values and the Mean of percentage of total phosphorus content for arid and non-arid Soils samples

Sample label	Total P(%)	Sample label	Total P(%)
Arid Soil sample 1	0.002	Ref. 1	0.029
Arid Soil sample 2	0.005	Ref. 2	0.055
Arid Soil sample 3	0.002	Ref. 3	0.052
Mean	0.003	Mean	0.045
SD	0.002	SD	0.014

IV. Conclusion

In conclusion, this study resulting has been the significant information that enable us to spot the array of the unique soil properties in hot places. Both arid and non-arid soils types possess the common property of coarse texture defined as dominant presence of sand. The Ks values thereon prove crucial. Arid soils tend to have lower Drainage/ Infiltration Constant Ks compared to soils in non-arid lands. This difference can significantly influence the outwelling dynamics of water, which is mostly seen in areas with arid climates. Furthermore, we saw that soils' respiration rates kept very small across both soil types which was an evidence of the minimal microbial activity in the release of carbon dioxide. The soil in both arid and, non-arid regions shows slightly acidic values of pH, providing adequate level of nutrients for crop development and growth. In contrast to this, the occurrence of highly concentrated salt in arid soils adds a big challenge in successful soil salinity management. To sum up, in arid soils, though SOM values are generally much lower than in other soils, this always is a consideration that the fertility enhancement as a way to help the optimal plant development is paramount. Closely related to this, a surprising scale of nutrients retention is indicated in both of the soil types by their moderate to medium cation exchange capacities (CEC). Even though both arid and moist soils had comparable total nitrogen (TN) levels, results showed that arid soil organic materials generally had lower levels of total phosphorus (TP) than moist soils, thus exposing a probable limitation in phosphorus mineralization, further stressing the need for precision in adoption of soil fertility protocols in arid environments. In summary, these results enlarge our knowledge of the soil's dynamics in Al-Najaf, thus confirming that devising informed decisions and adoptive management of the soil is essential for overcoming soil-related challenges and finding alternative methods for sustainable management of soil for the coming generations.

V. References

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