

Soil Quality Assessment in Al-Hamza Al-Gharbi District, Babylon Governorate Using Geographic Information Systems (GIS)

Teeba Mobarkah¹

Amal Radhi Jubier²

College of Agriculture, Al-Qasim Green University, Babylon, Iraq.

²Department of Soil Sciences and Water Resources, College of Agriculture, Al-Qasim Green University, Babylon 51013, Iraq. : <https://orcid.org/0000-0002-9156-8405>

*Correspondence to: Amal Radhi Jubier, Department of Soil Sciences and Water Resources, College of Agriculture, Al-Qasim Green University, Babylon 51013, Iraq

Email: amelradha@agre.uoqasim.edu.iq

Email: teebamobarkah@agre.uoqasim.edu.iq

Abstract

The study area is located in Al-Hamza Al-Gharbi District within the Babylon Governorate, between longitudes 44°30'00" to 45°05'00" E and latitudes 31°15'00" to 32°40'00" N. The total area of the study region is approximately 57,319 hectares. A semi-detailed soil survey was conducted using a grid-based sampling method, comprising 30 sampling sites at a depth of 0–30 cm using an auger drill, with a spacing of 300 meters between sites. The sampling locations were selected based on the variability of soil-forming factors and vegetation cover. Subsequently, eight representative soil pedons were identified. The coordinates of all sampling sites and pedons were recorded using a GPS device. Soil samples were collected from each horizon of the pedons for analysis.

The results revealed that soil quality in the study area falls into three categories: low, moderate, and high quality. The moderate quality class, with an index range of 1.13–1.45, covered the largest area of 34,230.53 hectares, accounting for 59.71% of the total study area. The low-quality class, with an index >1.45, covered the smallest area of 1,775.65 hectares (3.10%). The high-quality class, with an index <1.13, covered 21,326.26 hectares, representing 37.20% of the total area.

Keywords: Soil Quality, Evaluation, Agriculture, Geographic Information Systems (GIS).

Introduction

Soil quality refers to the capacity of a specific soil type to perform its functions. It has been defined by many researchers as the soil's ability to function within ecosystem and land-use boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health (Lal, 2015).

According to Armenise et al. (2013), soil quality reflects the relationship among physical, chemical, and biological properties of the soil in achieving one or more of its intended functional objectives. Any reduction in the performance of these functions for a specific purpose results in a decline in soil quality, which is expressed as a unitless numerical value derived from the integration of various soil properties.

Aziz et al. (2019) identified several indicators for calculating the Soil Quality Index (SQI), including texture, slope, gravel and stone content, drainage, parent material, organic matter, and carbonate mineral content. These indicators were used as criteria to assess desertification conditions in certain soils of the Kirkuk Governorate.

Hussein et al. (2020), in their study on soil quality assessment and land degradation in parts of Ethiopia, found that chemical indicators such as soil salinity, pH, exchangeable sodium percentage (ESP), and vegetation cover index provided clear explanations for reduced land productivity and decreased vegetation. The decline was attributed to increased salinity and vegetative expansion over agricultural lands, leading to

their degradation and reduced quality and productivity.

Damiba et al. (2024), in their evaluation of soil quality and sustainability in the Kakia catchment under three land use types in Narok County, Kenya, reported a decline in the Soil Quality Index due to water-induced erosion. This erosion led to environmental degradation and reduced crop yields as a result of the loss of fertile topsoil and poor land management practices. Soil quality was found to be low in grasslands, shrublands, and croplands. The study recommended periodic soil quality assessments to prevent land degradation, conserve and monitor soil moisture, and maintain soil sustainability. It emphasized using the Soil Quality Index as a decision-support tool and highlighted the need for intensified efforts to evaluate soil quality.

Given the importance of assessing soil quality, the objective of this study is to evaluate and classify soil quality types in the soils of Al-Hamza Al-Gharbi District in Babylon Governorate.

Materials and Methods

The study area is located in Al-Hamza Al-Gharbi District, Babylon Governorate, between longitudes 44°30'00" and 45°05'00" E, and latitudes 31°15'00" and 32°40'00" N. The total area of the study region is approximately 57,319 hectares. A semi-detailed soil survey was conducted using a grid sampling method consisting of 30 sampling sites at a depth of 0–30 cm. Samples were collected using an auger drill, with 300-meter spacing between each site. Sampling locations were determined based on the variability of soil-forming factors and vegetation cover. Subsequently, eight representative soil pedons were selected, and their horizons were described morphologically

according to the standard procedures outlined by the Soil Science Division Staff (2017). Coordinates for each sampling site and pedon were recorded using a Global Positioning System (GPS) device. Soil samples were collected from each horizon and sampling point, placed in labeled bags, and transported to the **laboratory for analysis**.

Electrical conductivity (ECe) was determined in the saturated soil paste extract using the method described by Black (1965). Soil gypsum content was determined by precipitation using an acetone solution following Richard (1954).

Calcium carbonate content was measured using hydrochloric acid (HCl), and the excess acid was back-titrated with 1N NaOH, according to Page et al. (1982). Organic matter content was determined using the wet oxidation method of Walkley and Black, as described in Jackson (1958).

Cation Exchange Capacity (CEC) was estimated using the ammonium acetate method (NH₄OAc) at pH 0.7, following Black (1965). The Soil Quality Index (SQI) was calculated using Equation (1) proposed by Basso et al. (2012):

SQI=

$$(\text{Pm} * \text{Text} * \text{Dr} * \text{EC} * \text{CaSO}_4 * \text{CaCO}_3)^{1/6} \text{-----}$$

--- (1)

Where:

SQI = Soil Quality Index, Pm = Parent Material Index, Text. = Soil Texture Class Index, Dr. = Drainage Class Index, EC = Electrical Conductivity Index (salinity), CaSO₄ = Calcium Sulfate Index, CaCO₃ = Calcium Carbonate Index

The values of the individual components of the equation were determined based on the criteria outlined by Al-Juraisi (2013), as shown in Table (1).

Table 1. Classes of Soil Quality Index Indicators and Their Weighted Index

Weighted Index	Criteria	Description	Classes	Indicators	Weighted Index	Criteria	Description	Class	Indicators
1	< 4 dS/m	Low	1	Sol Salinity	1	0-10	Good	1	Calcium Carbonate (%)
1.5	4-8	Moderate	2		1.2	10-20	Acceptable	2	
1.8	8-16	High	3		1.5	20-30	Medium	3	
2	> 16	V. High	4		1.8	30-40	High	4	
1	> 3	V. High	1	Organic Matter %	2	> 40	V. High	5	Soil Texture
1.2	3-2	High	2		1	L,SCL,SL,LS,CL	Good	1	
1.5	2-1	Moderate	3		1.2	SC,SiL,SiCL	Moderate	2	
1.7	1-0.5	Low	4		1.6	Si, C, SiC	Poor	3	
2	< 0.5	V. Low	5		2	S	V. Poor	4	
1	< 10	Good	1	Gypsum Content %	1	Mottling depth > 150 cm	Rapid	1	Drainage Condition
1.2	10-20	Acceptable	2		1.2	Mottling depth 150-90 cm	Good	2	
1.5	20-30	medium	3		1.4	Mottling depth 90-50 cm	Moderate	3	
1.8	30-40	High	4		1.6	Mottling -50 depth cm 25	Poor	4	
2	أكثر من 40	V. High	5		1.8	Mottling depth < 25 cm	Very Poor	5	
1	Shale, schist, ultra basic, conglomerates, nonconsolidated	Good	1	Parent Material	2	Waterlogged in upper horizon	Severely Poor (waterlogged)	6	
1.7	Limestone, , gnesis, siltstone, sandstone , Alluvial	Moderate	2						
2	Marl, Pyroclastic	Poor	3						

Results and Discussion:

In general, the soils of the study area exhibit good drainage, which is reflected by a drainage condition index value of 1.2 in Equation (1). The soils are classified as young alluvial deposits, originating from river sediments in a semi-arid climate, and are considered of good quality. Therefore, the parent material index (Pm) was assigned a value of 1 in Equation (1). According to the results presented in Table (2), soil texture classes in the study area range from Loam, Clay Loam, Silt Loam, Silt Clay Loam, Sandy Clay Loam, Silt Clay, to Clay. This variability in soil texture is attributed to sedimentation processes and the nature of fluvial deposits, particularly those originating from the Euphrates River in this region. Additionally, the intensity of river flooding and its variation in sediment load, transport, and deposition across different locations also contribute to this heterogeneity. These findings are

consistent with those reported by Jabbar (2023). Regarding gypsum content, a gradual increase in gypsum levels with soil depth was observed across the studied pedons. In cultivated soils, a reduction in gypsum content was noted, which can be attributed to its dissolution and leaching with irrigation water to deeper soil layers. Moreover, gypsum is inversely related to carbonate minerals, a relationship also identified by Mohammed (2022). Table (2) also indicates elevated levels of carbonate minerals in the study area. This is likely due to the presence of calcium carbonate salts, which are known for their low solubility. Furthermore, the parent material of the alluvial soils in the region is calcareous, and the climatic conditions characterized by high temperatures, low precipitation, and aridity favor the secondary precipitation and accumulation of carbonate minerals in the soil. These observations are in agreement with the findings of Jabbar (2023).

Table 2: Chemical Properties of the Soils in the Study Area

Site No.	Texture	ECe dSm ⁻¹	CaSO ₄ gKg ⁻¹	CaCO ₃ gKg ⁻¹	Site No.	Texture	ECe dSm ⁻¹	CaSO ₄ gKg ⁻¹	CaCO ₃ gKg ⁻¹
P1	L	3.72	7.45	156.7	S12	SiC	12.65	2.1	189.21
P2	C	3.84	6.12	172.91	S13	C	8.4	2.53	182.53
P3	SiCL	4.31	2.57	165.85	S14	SiCL	3.77	3.32	163.04
P4	SiCL	4.13	8.69	182.54	S15	SiCL	3.86	2.81	154.7
P5	CL	23.47	2.03	301.79	S16	SiL	11.3	0.95	200.36
P6	L	17.91	1.17	204.27	S17	SCL	32.1	5.79	185.69
P7	C	31.28	9.73	324.8	S18	SiC	4.82	4.11	161.38
P8	C	16.47	2.61	255.62	S19	L	3.28	5.05	170.33
S1	SiC	4.39	3.54	162	S20	SCL	30.4	1.19	235.45
S2	SiCL	5.21	1.9	200.31	S21	C	3.15	3.64	181.17
S3	SiL	16.22	3.23	141.24	S22	CL	4.07	4.05	179.03
S4	CL	20.08	1.08	247.1	S23	C	3.6	4.28	153.91
S5	C	3.23	2.18	174.35	S24	SCL	4.21	3.65	182.56
S6	SiCL	3.11	3.06	165.23	S25	SiL	32.02	1.1	218.83
S7	SiL	5.6	2.45	181.11	S26	CL	25.1	1.23	201.7
S8	L	3.81	3.12	163.9	S27	SCL	5.4	4.38	168.51
S9	L	4.55	1.4	180.55	S28	CL	3.82	4.56	162.05
S10	SiCL	6.63	1.32	164.38	S29	SiCL	3.55	5.11	154.7
S11	SiL	20.42	0.98	221.15	S30	SCL	24.04	0.78	248.03

The results presented in Table (2) and Figure (1) indicate that the spatial distribution of soil quality classes in the study area is categorized into three classes. The class with moderate quality, falling within the range of 1.13–1.45, occupies the largest area, amounting to 34,230.53 hectares, which constitutes 59.71% of the total study area. The low-quality class, with values greater than 1.45, covers the smallest area of 1,775.65 hectares, representing 3.10%. Meanwhile, the

high-quality soil class, with values less than 1.13, extends over 21,326.26 hectares, accounting for 37.20% of the total area. Soil quality is demonstrated through its capacity to support plant growth and crop productivity, which is influenced by the quality of the soil's physical, chemical, and biological properties (Reitsma et al., 2011). These findings are consistent with the results reported by (Al-Shammari, 2024).

Table 3: Weighted Indicators of Soil Quality Index Criteria and Their Values

Site No.	Index Pm	Index texture	Index Dranaig	Index ECe	Index Gypsum	Index Lime	SQI
P1	1	1	1.2	1	1	1.2	1.06
P2	1	1.6	1.2	1	1	1.2	1.15
P3	1	1.2	1.2	1.5	1	1.2	1.17
P4	1	1.2	1.2	1.5	1	1.2	1.17
P5	1	1	1.2	2	1	1.8	1.28
P6	1	1	1.2	2	1	1.2	1.19
P7	1	1.6	1.2	2	1	1.8	1.38
P8	1	1.6	1.2	2	1	1.5	1.34
S1	1	1.6	1.2	1.5	1	1.2	1.23
S2	1	1.2	1.2	1.5	1	1.2	1.17
S3	1	1.2	1.2	2	1	1.2	1.23
S4	1	1	1.2	2	1	1.5	1.24
S5	1	1.6	1.2	1	1	1.2	1.15
S6	1	1.2	1.2	1	1	1.2	1.10
S7	1	1.2	1.2	1.5	1	1.2	1.17
S8	1	1	1.2	1	1	1.2	1.06
S9	1	1	1.2	1.5	1	1.2	1.14
S10	1	1.2	1.2	1.5	1	1.2	1.17
S11	1	1.2	1.2	2	1	1.5	1.28
S12	1	1.6	1.2	1.8	1	1.2	1.27
S13	1	1.6	1.2	1.8	1	1.2	1.27
S14	1	1.2	1.2	1	1	1.2	1.10
S15	1	1.2	1.2	1	1	1.2	1.10
S16	1	1.2	1.2	1.5	1	1.2	1.17
S17	1	1	1.2	2	1	1.2	1.19
S18	1	1.6	1.2	1.5	1	1.2	1.23
S19	1	1	1.2	1	1	1.2	1.06
S20	1	1	1.2	2	1	1.5	1.24
S21	1	1.6	1.2	1	1	1.2	1.15
S22	1	1	1.2	1.5	1	1.2	1.14
S23	1	1.6	1.2	1	1	1.2	1.15

S24	1	1	1.2	1.5	1	1.2	1.14
S25	1	1.2	1.2	2	1	1.5	1.28
S26	1	1	1.2	2	1	1.5	1.24
S27	1	1	1.2	1.5	1	1.2	1.14
S28	1	1	1.2	1	1	1.2	1.06
S29	1	1.2	1.2	1	1	1.2	1.10
S30	1	1	1.2	2	1	1.5	1.24

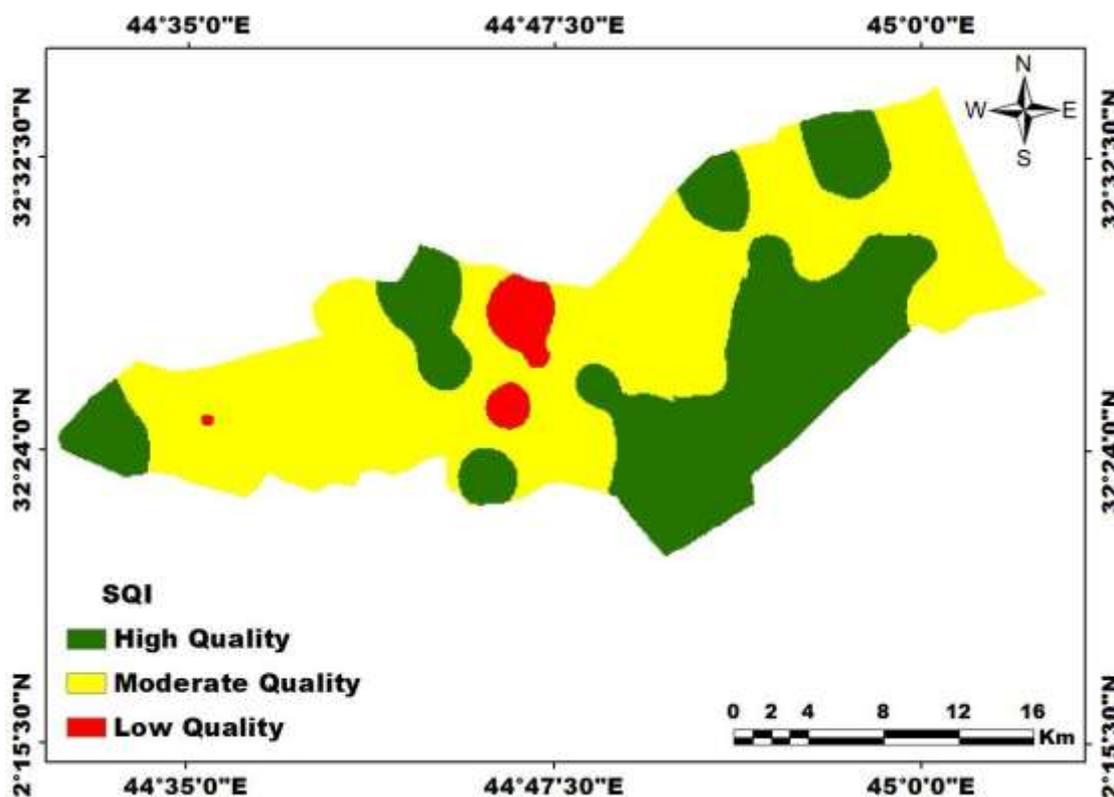


Figure 1: Spatial Distribution of Soil Quality Classes in the Study Area

Conclusion

The evaluation of soil quality and the classification of its categories rely on the integrity of its various properties. Chemical soil quality, in particular, plays a crucial role in soil sustainability, as well as in maintaining its productive capacity and overall quality.

References

- **Al-Juraissi**, Salah Murshid (2013). *Land Degradation Classification within the Ayman Al-Furat and Saqlawiyah Project Areas and Its Relationship to the Physiographic Position Using Geo-information Technologies*. PhD Dissertation, College of Agriculture, University of Anbar.
- **Armenise E.**, Redmile-Gordon M.A., Stellacci A.M., Ciccacese A., Rubino P. (2013). "Developing a soil quality index to compare soil fitness for agricultural use under different managements in the Mediterranean environment." *Soil and Tillage Research*, 130, 91–98.
- **Aziz**, Dilshad Rasool; Asin Ali Raza; Mohammed Bashar Omar; Lazgin Haidar Fakhraddin; Ahmed Muhieddin Hashem; Aisha Irfan Ibrahim (2019). *Assessment of Desertification Status Using Soil Quality Index under the MEDALUS Model for Selected Areas in Kirkuk Governorate*. The

3rd International Scientific Conference on Agricultural Sciences – Postgraduate Studies. *Kirkuk University Journal of Agricultural Sciences*, pp. 625–635.

- **Basso, B., L. De Simone, D. Cammarano, C.E. Martin, S. Margiotta, R.P. Grace, M.L. Yeh and T.Y. Chou.** 2012. Evaluating responses to land degradation mitigation measures in Southern Italy. *International Journal of Environmental Research*, 6:367-380.
- **Black, C . A .**(1965). Methods of soil analysis. Part 1 Physical Properties. Am. Soc. Agron. Madison. Wisconsin , USA .
- **Damiba, Wendyam Arsene, John Mwangi Gathanya, James Messo Raude, and Patrick Gathogo Home.** (2024). Soil quality index (SQI) for evaluating the sustainability Status of kafia- Esamburmbur catchment under three different land use types in Narok County, Kenya. *Hellyon* 10, e25611.
- **Hussien, K.,Woldu,G., and Birhanu,S.**(2020). AGIS-based multi –Criteria land Suitability analysis for surface irrigation along the Erer Watershed, Eastern Hararghe zone, Ethiopia. *Est African Journal of Science*, 13(2),169-184.
- **Jabbar, Rania Hassan** (2023). *Soil Characteristics of the Western Canal Project / Karbala Governorate and Their Suitability for Wheat Cultivation Using Geospatial Technologies*. PhD Dissertation, College of Agriculture, Al-Qasim Green University.
- **Jackson , M . L .** (1958) . ``Soil chemical Analysis `` . printice – Hall . Inc . , Engle wood cliffs . , N . Y .
- **Lal ,Rattan** (2015) .Restoring Soil Quality to Mitigate Soil Degradation .Sustainability ,Vol.7(5),5875-5895.
- **Mohammed, Hani Rabie** (2022). *Environmental Sensitivity to Desertification in the Northwest of Beni Suef Governorate Using the MEDALUS Model. The Geographical Journal*, issued by the Egyptian Geographical Society, Issue 171.
- **Page, A. L., R. H. Miller and D. R. Kenney.** (1982). *Methods of Soil Analysis Part (2)* . 2nd ed. Agronomy 9 Am. Soc. Agron. Madison, Wisconsin .
- **Richards, L . A .** (1954) . Diagnosis and improvement of saline and alkaline soils . U.S.D.A. Handbook No . 60 .