ASSESSMENT OF SOIL QUALITY AND HEALTH USING SOME PHYSICAL AND BIOLOGICAL PROPERTIES FOR FADAK FARM PROJECT

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ABSTRACT

Fadak farm project was selected to conduct this study and to evaluate the state of quality and health indices in term of soil physical and biological properties, where this farm is located in Holly Najaf Governorate. Some physical properties (soil texture, mean weight diameter, bulk density, porosity, infiltration rate, saturated hydraulic conductivity and available water) were selected to assess the quality then health indices, and the biological characteristics (vegetation coverage, soil respiration, bacterial and fungal counts) were also selected to assess the quality and health indices in term of these properties. Results showed that classes of moderate and poor soil health were dominated in lands of this farm for each physical and biological properties. It was noted that the class good of soil health was collaterally appeared in small areas according to biological characteristics.

Keywords: Desertification, Microbial biomass Soil respiration

تقييم نوعية وصحة التربة باستخدام بعض صفات التربة الفيزيائية والاحيائية لمشروع مزرعة فدك/محافظة النجف الاشرف

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المستخلص

تم اختيار مشروع مزرعة فدك لإجراء هذه الدراسة وتقييم نوعية التربة والمؤشرات الصحية من حيث الخصائص الفيزيائية والحيوية للتربة ، حيث تقع هذه المزرعة في محافظة النجف الأشرف. تم اختيار بعض الخصائص الفيزيائية (نسجة التربة، معدل قطر الوزن، الكثافة الظاهرية، المسامية، معدل الغيض، الايصاليةالمائية المشبعة والماء الجاهز) وبعض الخصائص البيولوجية (تغطية الغطاء النباتي، تنفس التربة، الكتلة الحيوية الميكروبية) لتقييم مؤشرات نوعية وصحة التربة. أظهرت النتائج أن اصناف التربة المعتدلة والضعيفة كانت السائدة في أراضي هذه المزرعة لكل من الخصائص الفيزيائية والحيوية. بينما لوحظ واعتماداً على الخصائص البايولوجية أن الصنف الجيد لصحة التربة ظهرت بشكل ضمني في مناطق صغيرة.

الكلمات المفتاحية: التصحر، الكتلة الحيوية البايولوجية، تنفس التربة

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INTRODUCTION

Soil health is defined as the continuous capability of the soil to function as a living biological ecosystem that preserves humans, animals and plants, and it is a combination of the physical, chemical and biological properties of the soil that can easily change depending on environmental conditions and changes (8, 44). Soil quality and soil health are the two terms used to describe the functional state of soil. They describe the capability of soil to maintain crop productivity, environmental quality, and support plant, animal, and human health. The term "soil biological health" can be used to refer to the biological function of soil in relation to plant growth, yield and productivity (45). The use of the term "soil health" emphasizes that a soil ecosystem requires maintenance and conservation to maintain the biodiversity and biological activity. Karlen (34) stated that the concept of soil health has evolved over the past several decades and they emphasized the need to advance scientifically in monitoring and evaluation protocols through (a) improving indicators recording tools (b) developing national monitoring protocols (c) identifying new soil biological, physical indicators of soil health. They also emphasized that producers' interest in soil health monitoring and region-appropriate interpretation remains strong. To meet these needs, the USDA-Norwegian Red Cross and USDA have initiated the Cascade Analysis Project that focuses on the interpretation of indicators and the development of tools. Healthy soils are critical to the health of ecosystems, economies and populations. Hence, it is widely recognized that soil health is important for quantification, both for assessment and as a tool to help guide management strategies. What is less clear is how soil health is actually measured, especially given that soil health is not exclusively a product of soil physical and chemical properties. Because of their well-established importance to many aspects of soil health, microbiology and bioactivity are often used as measures of soil health with a range of different biota-based measures routinely found around the world (18). The current study aims to: Assessment of the health of the soil units of the Fadak farm project by adopting health evidence. Also, indication of the effect of variability in vegetation overland cover and use type in the variance of biophysical quality indices for the study area. And to diagnose the condition and degree of deterioration in the soil units of the region and develop administrative solutions for them.

MATERIALS AND METHODS

study area: The Fadak farm project was chosen in the governorate of Najaf. The project is located in the northwestern side of the governorate of Najaf, within the coordinates 40600 to 418000 North and 3537000 to 3545000 East. The total area of the project is estimated at 35943 ha Figure 1 shows a map of Iraq on which the project site is located.

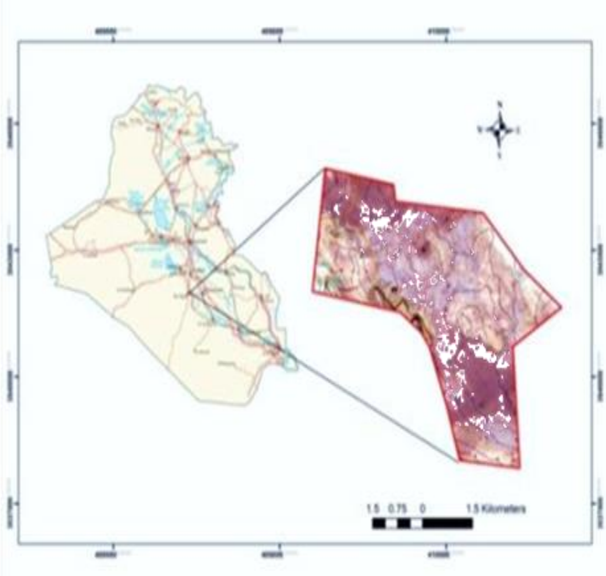

Figure 1. location map of Fadak farm

Office methodology: Prepared maps by the National Center for Water Resources of the Research and Design Department / Division of Hydrological Investigations and Land Classification of the Ministry of Water Resources in preparation were used for field visits. As well as used later in the production maps of soil characteristics under the GIS environment using ArcGIS 10.3.

Field methodology: Before starting sampling, the study area was visited to determine the locations of pedons as well as to determine the locations of the surface samples. It was taken into consideration while defining the paths and the study plots that they cover most of the project lands and in different directions. As 40 random surface samples representing the farm were taken from a depth of 0-0.3 m using the auger drilling machine. Eight pedons representing the soil of the study area were excavated and its horizons were described in a fundamental morphological description according to the Soil Survey Staff (46).

laboratory procedures

Soil samples were dried and divided into two parts, the first was left without grinding or sieving in order to measure mean weight diameter, while the soil samples for the second part were ground and passed through a sieve with 2 mm openings in diameter and the necessary measurements were taken on it.

physical properties

particle size distribution was determined according to the method given in (43). Soil bulk density was estimated using the core method according to the Blake and Hartge method described in (37). Porosity was calculated through the mathematical relationship between both the bulk and particle density as stated by (23) and according to the following equation.

$$f = 1 - \frac{\rho_b}{\rho_s} \qquad (1)$$

Since: f= soil porosity (percentage). ρ_s= partical density (µg m^{-3}). ρ_b= bulk density (µg m^{-3}). Water infiltration was measured using Mini Disc Infiltrometer (MDI).

The saturated hydraulic conductivity was measured according to the . method described by (37) using a standing water column on unstimulated soil models *(*Equation 2*)*.

$$K_{sat} = \frac{VL}{At\Delta H} \qquad (2)$$

Since: K: Saturated hydraulic conductivity V: Infiltrated water volume (cm^3), L: Soil Column Length (cm), A: flow-section area (cm^2), t: Water collection time (hour), ΔH:The change in water potential between its entry and exit point Soil resistance to penetration: use a pocket penetrator pocket penetrometer CL 700 has a cylindrical stem and flat end with a diameter of 0.672 cm and a penetration depth of 1 cm from the surface to measure soil penetration resistance was measured according to the method proposed by (15). Mean weight diameter was determined using the method suggested by (52). Available water was calculated by the difference between volumetric moisture content at field capacity and permanent wilting point using pressure discs according to the method mentioned in (9).

Biological properties

Total soil bacterial and fungal counts: It were done according to the methods presented in (6). Soil respiration: Soil respiration was measured by the production of carbon dioxide gas using a carbon dioxide meter device according to the method presented in (21, 24). Organic Carbon and Organic Matter: The percentage of organic matter was estimated after estimating the organic carbon and converting the values to the organic matter content in the soil by the wet oxidation method according to the Walkley Black method described by (33).

Organic matter (%) = Total organic carbon (%) × 1.72 (3)

vegetation coverage: Use the application Canopic to extract the value of the vegetation cover on the soil surface to isolates the green cover in a specific area from the rest of the covers and calculates the percentage of vegetation cover percentages, the program is a multi-purpose green cover measurement tool developed by Soil Physics Research Group (http:// soilphysics. okstate. edu/) and (https://appcenter.okstate.edu/) at Oklahoma State University. http://canopeoapp.com

Indices of soil quality and health: The soil quality index was calculated by adopting the physical and biological characteristics, each separately, through the values of the measured properties, as well as the dual overlap of all the properties. The current study is for the purpose of calculating the soil quality and health indices for the mentioned properties, and then the dual overlap of the combined properties.=

Soil quality and health indices in relation to physical properties:

$$SQI_{physical} = (\text{Soil texture} \times MWD \times BD \times Porosity \times PR \times HC \times Inf. \times AW)^{1/8} \quad (4)$$

Whereas:

MWD= mean weight diameter, BD= bulk density, PR= penetration resistance, HC= saturated hydraulic conductivity, inf.= infiltration rate.

Soil quality and health indices in relation to biological properties:

properties phy	Content	SQI	Soil health
Texture	coarse	1	Poor
	fine	2	Moderate
	medium	3	Good
BD μ m^{-3}	<1.25	3	Good
	1.25-1.4	2	Moderate
	>1.4	1	Poor
MWD mm	2-1.3	3	Good
	1.3-0.8	2	Moderate
	>0.8	1	Poor
Infiltration cm	>8	2	Moderate
	8-4	3	Good
	<4	1	Poor
K sat Cm h^{-1}	<0.15	1	Poor
	0.15-5.07	3	Good
	>5.07	2	Moderate
Penetration Kpa	<50	3	Good
	50-196	2	Moderate
	>196	1	Poor
AW cm^3cm^{-3}	>0.175	3	Good
	0.175-0.10	2	Moderate
	<0.100	1	Poor

$$SQI_{biological} = (fungi \times bacteria \times vegetation \times CO_2\ Soil\ respiration)^{1/4} \quad (5)$$

Whereas:
Fungi = number of fungal colonies, Bacteria = number of bacterial colonies, Vegetation = percentage of plant coverage, CO_2 soil respiration = soil respiration (carbon dioxide concentration).
The following categories were used in assessing the degree of soil quality and health index:

Parameter bio	Content	SQI	Soil health
Vegetation coverage %	<25%	1	Poor
	25-75%	2	Moderate
	>75%	3	Good
CO_2 ppm	0-200	1	Poor
	200-500	2	Moderate
	>500	3	Good
fungi CFU	<10^4	1	Poor
	10^4-10^6	2	Moderate
	>10^6	3	Good
Bacteria cfu g^{-1}	<10^5	1	Poor
	10^5-10^8	2	Moderate
	>10^8	3	Good

Soil quality and health index for all physical and biological characteristics

$$SQI_{Total} = (SQI\ physical \times SQI\ biological)^{1/2} \quad (6)$$

Whereas:
SQI_{total} = total soil health index,
$SQI_{physical}$ = soil quality index for physical characteristics, $SQI_{biological}$ = soil quality index for biological characteristics. The physical and biological indicators were adopted for the purpose of assessing the quality and health of the soil in the current study according (48).

RESULTS AND DISCUSSION

Particle size distribution

The results of the mechanical analysis of surface soil samples in the study area shown in the table (2) However, the textures of the soils that were studied were coarse and medium in general. It is noted that the sand content is high throughout the study area compared to the content of clay and silt, and the sand content ranged between 336-776 gkg^{-1}, while the clay content ranged between 260-152 g kg^{-1}, and the silt content between 64-424 gkg^{-1}. The reason for the high content of sand compared to the content of clay and silt is due to the nature of sedimentation taking place in the desert study area, where these soils are desert that originally originated from ancient marine sediments from the bottoms of the ancient sea of Tethys, which covered most of the study area, as well as the wind sediments that are common in which rough separation of separates (4, 9, 12). It is noted that the clay content showed the least spatial heterogeneity compared to the content of sand and silt, and the reason is due to the fact that most of the soil textures of the study area were within the textures of coarse and medium texture, where the content of sand separated in them increases compared to the fine separated, which is clay, which is reflected in the variation in the content of both, as well as About the emergence of more varieties as protomorphic units on the spatial distribution map due to the wide range of sand and silt content compared to the content of clay. The result of these medium textures led to the predominance of the cultivation of grain crops in the project area, especially wheat and barley as well as greenhouse agriculture.

bulk density

Table (1) shows the values of the bulk density of the study area in general, which ranged between 1.32 - 1.51 $Mg.m^{-3}$. Although all samples of the study area were generally of coarse texture, the decrease in the value of the bulk density was due to the nature of the land use for that site, as a significant decrease in the value of the bulk density in the greenhouse agricultural areas and the fields of alfalfa and wheat due to the field management applications by adding organic matter (humus) and plant residues, which was positively reflected on the values of the bulk density, which led to a decrease in those values, while an increase in the values of the bulk density is noted in the areas of barren lands, not cultivated and reclaimed lands, and because of the predominance of coarse grained in it, the values of the bulk density increased (36, 39).

Table 1. The physical characteristics of the soil of the study area

NO.	Sand	Clay	Silt	Texture	ρb	porosity	MWD	infiltration	K sat	Soil Pent	AW
	g kg^{-1}				μ m^{-3}	cm^3cm^{-3}	mm	cm	cm hr^{-1}	Kpa	cm^3cm^{-3}
1	616	160	224	SL	1.50	0.43	0.121	11.06	2.150	215.9	0.091
2	496	200	304	L	1.42	0.46	0.112	9.23	1.093	216.6	0.112
3	536	200	264	SL	1.45	0.45	0.133	13.17	1.272	175.3	0.106
4	456	240	304	L	1.38	0.47	0.311	9.01	0.820	166.5	0.120
5	576	220	204	SCL	1.46	0.44	0.115	12.94	1.124	216.4	0.088
6	436	200	364	L	1.39	0.47	0.270	7.21	1.040	180.8	0.126
7	336	240	424	L	1.38	0.47	0.250	5.18	0.566	187.6	0.090
8	636	180	184	SL	1.42	0.46	0.256	14.63	1.918	177.6	0.088
9	356	240	404	L	1.38	0.47	0.287	5.73	0.630	182.2	0.128
10	716	160	124	SL	1.38	0.47	0.330	17.24	2.906	144.7	0.076
11	776	160	64	SL	1.39	0.47	0.312	17.31	3.240	151.2	0.065
12	676	160	164	SL	1.40	0.47	0.300	16.01	2.622	167.5	0.082
13	496	180	324	L	1.45	0.45	0.112	10.16	1.237	216.1	0.113
14	576	200	224	SL	1.32	0.50	0.156	12.66	1.407	188.6	0.098
15	696	180	124	SL	1.39	0.47	0.183	14.25	2.223	182.1	0.077
16	596	240	164	SCL	1.36	0.48	0.292	12.42	1.034	169.2	0.095
17	636	260	104	SCL	1.49	0.43	0.113	13.72	0.870	215.5	0.090
18	630	250	120	SCL	1.37	0.48	0.196	13.79	0.932	168.3	0.089
19	656	220	124	SCL	1.34	0.49	0.188	14.16	1.369	183.1	0.084
20	696	200	104	SL	1.42	0.46	0.142	16.22	1.736	182.3	0.075
21	540	198	262	SL	1.45	0.45	0.117	13.21	1.281	173.3	0.107
22	621	157	222	SL	1.5	0.43	0.121	11.1	2.147	168.9	0.096
23	499	197	304	L	1.42	0.46	0.223	9.22	1.094	177.1	0.112
24	578	218	204	SCL	1.46	0.44	0.148	11.07	2.161	215.9	0.092
25	441	199	360	L	1.39	0.47	0.342	7.29	1.044	169.9	0.125
26	435	201	364	L	1.39	0.47	0.248	7.19	1.039	171.2	0.132
27	709	152	139	SL	1.38	0.47	0.276	17.21	2.905	151.7	0.079
28	752	161	87	SL	1.39	0.47	0.268	17.34	3.23	154.2	0.067
29	675	159	166	SL	1.4	0.47	0.281	16.04	2.619	161.8	0.077
30	597	240	163	SCL	1.36	0.48	0.273	12.44	1.031	164.4	0.098
31	701	198	101	SL	1.42	0.46	0.185	16.19	1.74	192.1	0.069
32	697	201	102	SL	1.42	0.46	0.111	16.23	1.738	223.4	0.069
33	501	189	310	L	1.45	0.45	0.165	10.15	1.237	215.9	0.116
34	638	258	104	SCL	1.49	0.43	0.169	13.69	0.868	195.8	0.090
35	651	220	129	SCL	1.34	0.49	0.188	14.16	1.369	190.1	0.084
36	634	251	115	SCL	1.37	0.48	0.107	13.79	0.932	228.3	0.089
37	620	174	206	SL	1.46	0.44	0.124	14.21	2.352	175.1	0.133
38	590	198	212	SL	1.51	0.43	0.167	13.55	1.895	171.3	0.060
39	490	230	280	L	1.36	0.48	0.120	13.87	1.254	230.5	0.103
40	501	202	297	L	1.38	0.47	0.113	14.21	1.877	225.7	0.129

Total porosity: The total porosity values in the study area ranged between 0.43 - 0.50 cm^3cm^{-3}. it is noted that low values of porosity are associated with higher sand content, whereby an increase in the coarse separation leads to a decrease in the porosity, while the latter's values are lower than the high content of the fine sand (35, 40). as it is noted that the porosity variety, which lies between 0.45-0.47 cm^3cm^{-3} is dominant, followed by the variety 0.43-0.45 cm^3cm^{-3}, while the variety with the range 0.47-0.5 cm^3cm^{-3} was the least distributed in the study area, this was also affected by land uses in the study area, where the increase in porosity values was related to the content of fine separate on the one hand, and land use on the other.

Mean weight diameter: Table (1) shows the values of the mean weight diameter of the study area, which ranged between 0.20 - 0.373 mm. Although the texture of the area is coarse and medium coarse in general, a noticeable increase was observed in some areas of the farm, especially in the areas of palm and pomegranate cultivation, as well as greenhouses as well as the fields of alfalfa where this rise is attributed to the soil management practices and reclamation processes applied to those areas, including the addition of organic materials and improvers, which led to this rise in values compared to the rates of barley lands and unused lands of the farm so far. (16,38,44,45).

Soil water infiltration: Table (1) shows that there are high differences in the values of the cumulative infiltration according to the type of cultivated vegetation, whose value ranged in 3600 seconds between 5.18 - 17.34 cm h^{-1}, and that the lowest cumulative infiltration in the soil was under the cover of greenhouse cultivation, followed by the lands that were prepared for the cultivation of vegetables, while the highest value was recorded in the fallow and barren lands, and the reason is due to the accumulation of salts in some of the fallow lands, as well as the lack or of organic matter, which leads to a decrease in the soil holding capacity for water and consequently the high value of the infiltration as well as the main effect on the soil of the study area, where those resulted was also found (3, 5, 6, 19, 51).

saturated hydraulic conductivity: Table (1) shows the values of the hydraulic conductivity of the soils of the study sites, where the results recorded the highest value of the saturated hydraulic conductivity was 3.24 cm min^{-1} in greenhouses cultivation areas, while the lowest value was recorded 0.566 cm.min^{-1} in the fallow and barren lands of the farm due to the texture class of the study area in general, its inability to hold or retain water, the lack of organic matter in the fallow lands, and the absence of soil conditioners, on the contrary, what is found in the cultivated lands. It is also noted that there is a clear trend in the correlation of the saturated water conductivity values with the infiltration rate, as with the increase of the latter, the saturated hydraulic conductivity values increase. (1, 2, 32, 49).

Resistance to root penetration: Table (1) shows that the values of soil penetration by roots ranged between 157.6-230.Kpa This rise is due to the formation of a hard surface crust in most areas of the farm, especially in the uncultivated lands. It is also noted from the table that the values decreased in the cultivated areas, the greenhouse cultivation areas and the areas of palm, pomegranate, pistachio and wild jujube trees because of the plowing and the breaking up of the soil and the surface crust, which led to a decrease in values of this property in these areas, in addition to the relatively high content of organic matter in the soil in those areas compared to the fallow areas, also soil texture plays a major role in the effect on the values of penetration resistance, where the values of the penetration resistance of the roots in the study area are relatively high due to the high content of sand in them compared to clay soils and soils with a high content of organic materials due to the effect of the sand content in increasing the friction when measuring this characteristic with the penetrometer (14, 23, 27).

Available water: It is noted from Table (1) that the available water values ranged between 0.060-0.133cm^3cm^{-3}, where the values of the available water content were related to the soil texture. In the soils with loam and sandy clay loam textures, the values of the available water were higher than in sandy loam soils, due to the fact that the total pore size in soils with a higher clay content is much higher than soils with a higher content of coarse separates, although the diameter of the pores in coarse-textured soils is higher than that of fine-textured soils, and this was confirmed by all references in soil physics and water sciences (11, 28, 29, 30).

Biological Characteristics:

vegetative coverage: Table (2) shows the percentages of plant coverage for the study area, as this percentage reflects the situation of the area in general, whether it is exploited or not, as the coverage of the study areas ranged between 0-93%, where the values were recorded between 0-7 in completely fallow lands and lands where some predominated by natural plants spread within the sampling area, while the values that ranged between 15.60-93 were in the rest of the cultivated study areas, starting with the fields of pistachio, wild jujube, palm and pomegranate bushes, up to the greenhouses and alfalfa fields that took the highest values. Where the cultivar with vegetation coverage prevailed in the region 0-25% of the total area, which represents most of the abandoned areas and some areas of modern cultivation of pistachio and wild jujube bushes, followed by the cultivar 50-75% of dominance, which is represented by areas of cultivation of grain crops for the current season and the residuals of the previous season after harvesting as management systems were followed in the crop residues after harvest to improve the properties of the soil in general, as well as some areas of palm trees and some other fruit trees.

Soil respiration (concentrationCO_2): Table (2) shows the values measured by a carbon dioxide meter (CDM) device for the farm areas, which ranged between 215-847 ppm at a temperature of 30°C, as these values differed according to the type of vegetation and the type of plant grown for each of the farm regions. When the cultivated areas in general recorded higher values, ranging between 386-847 ppm, and the difference in this respiration rate was due to the type of planted crops and the density of the plants in the same measured area, as it gave the highest value in the alfalfa field. In the roots of the plant and its proximity to the surface layer of the soil, as well as the high density of the planted alfalfa plant, followed by the protected cultivation areas, which recorded different values ranging between 728-793 ppm, depending on the different type of planted in the greenhouses, as well as the percentage of adding organic matter and humus. It is noted from the results that the predominance of the class 215-400 ppm, which is the weakest in the study area, and the reason is due, as we mentioned earlier, to the nature of the land uses.

Bacterial numbers: Table (2) shows the values of soil content of bacterial numbers, as it ranged between 4×10^5 - 31×10^8 colonies cfu g^{-1} soil. It is noted that there is a wide range of bacterial colonization values in the soil of the study area, and the reason is certainly due to the nature of the land uses in each area, as low values of bacterial density were found in the abandoned areas and some areas with little vegetative coverage, while high values of bacterial density spread in the areas of highly used, especially in the areas of cultivar and grain crops, and the reason is may due to the increase in the activity of microorganisms in the root zone of those areas. (13, 17, 50).

Fungi communities: Table (2) shows the values of the soil content of the fungal numbers, which ranged between 2×10^3 - 22×10^3 cfu g^{-1}, which are less than those found on the surface of fertile soil, that amount to 4×10^5 cfu g^{-1}. This decrease may due to the drought and lack of nutrients in desert soils. These small values also varied in their spread over the area of the study area according to the land use of each region, as the values of fungal density increased proportionately in the greenhouse lands and the alfalfa fields, where the number of fungi in those lands reached 22 $\times10^3$ and 20 $\times10^3$ cfu g^{-1} respectively, while the highest value was recorded in unused and fallow lands at 6.5×10^3 cfu g^{-1}. The reason for this increase is due to the management practices used on the cultivated lands to provide a moist environment and the addition of organic materials, which led to a clear increase in the number of fungi in these areas.

Table 2. The biological characteristics of the soil of the study area

NO	Vegetation %	CO_2 ppm	Fungi cfu g^{-1}	Bacteria cfu g^{-1}
1	7	286	4×10^3	6×10^4
2	6	295	35×10^2	6×10^4
3	4	251	6×10^3	8×10^4
4	46	556	19×10^3	21×10^6
5	7	220	4×10^3	4×10^4
6	49	635	18×10^3	22×10^6
7	51	460	17×10^3	21×10^6
8	47	386	15×10^3	18×10^6
9	55	500	19×10^3	20×10^6
10	91	728	21×10^5	30×10^8
11	91.3	793	22×10^5	41×10^8
12	92	847	20×10^5	48×10^8
13	0	276	5×10^3	7×10^4
14	5	262	65×10^2	8×10^4
15	15.6	413	19×10^3	20×10^6
16	93	600	19×10^5	46×10^8
17	3	247	6×10^3	5×10^4
18	6	273	8×10^3	9×10^4
19	80	286	15×10^5	19×10^8
20	0	221	3×10^3	5×10^4
21	1	250	37×10^2	5×10^4
22	0	289	3×10^3	4×10^4
23	1	255	98×10^2	97×10^3
24	12	255	7×10^3	25×10^4
25	67	238	30×10^4	9×10^7
26	59	480	18×10^3	20×10^6
27	87	780	21×10^4	19×10^8
28	90	790	21×10^4	19×10^8
29	80	750	23×10^4	12×10^8
30	82	556	11×10^4	96×10^6
31	0	240	9×10^3	95×10^3
32	0	230	35×10^2	4×10^4
33	1	245	12×10^3	9×10^4
34	1	215	8×10^3	9×10^4
35	7	650	7×10^3	8×10^4
36	7	358	41×10^2	5×10^4
37	1	270	4×10^3	4×10^4
38	1	254	3×10^3	5×10^4
39	0	230	3×10^3	4×10^4
40	1	290	3×10^3	4×10^4

Soil quality and health indices: The soil quality index known as SQI is a set of properties that provide numerical data related to the ability of soil to perform one or more functions, while soil health is an assessment of how well the soil performs all of its functions currently and how these functions are maintained for future use (31, 46, 47). The soil quality index for the Fadak farm project in Najaf Governorate was measured by adopting a set of physical properties to set up the SQI.

Table 3. values of the soil quality and health indices

SN	SQI phy	Class	SQI bio	Class	SQI total	Class
1	1	poor	1	poor	1	poor
2	2	moderate	1	poor	2	moderate
3	1	poor	1	poor	1	poor
4	2	moderate	2	moderate	2	moderate
5	1	poor	1	poor	1	poor
6	2	moderate	2	moderate	2	moderate
7	2	moderate	2	moderate	2	moderate
8	1	poor	2	moderate	2	moderate
9	2	moderate	2	moderate	2	moderate
10	2	moderate	3	good	3	good
11	2	moderate	2	moderate	2	moderate
12	1	poor	3	good	2	moderate
13	2	moderate	1	poor	2	moderate
14	1	poor	1	poor	1	poor
15	2	moderate	2	moderate	2	moderate
16	2	moderate	3	good	3	good
17	2	moderate	1	poor	2	moderate
18	2	moderate	1	poor	2	moderate
19	2	moderate	2	moderate	2	moderate
20	1	poor	1	poor	1	poor
21	1	poor	1	poor	1	poor
22	1	poor	1	poor	1	poor
23	2	moderate	1	poor	2	moderate
24	1	poor	1	poor	1	poor
25	2	moderate	2	moderate	2	moderate
26	2	moderate	2	moderate	2	moderate
27	2	moderate	3	good	3	good
28	2	moderate	3	good	3	good
29	1	poor	3	good	2	moderate
30	2	moderate	2	moderate	2	moderate
31	1	poor	1	poor	1	poor
32	1	poor	1	poor	1	poor
33	2	moderate	1	poor	2	moderate
34	2	moderate	1	poor	2	moderate
35	2	moderate	1	poor	2	moderate
36	2	moderate	1	poor	2	moderate
37	1	poor	1	poor	1	poor
38	1	poor	1	poor	1	poor
39	2	moderate	1	poor	2	moderate
40	2	moderate	1	poor	2	moderate

Soil quality and health index in relation to physical properties: The soil quality index was measured for the physical characteristics, as the soil texture, bulk density, porosity, weighted diameter rate, infiltration, saturated water conductivity, soil penetration, and ready water were selected by adopting the limits of field capacity and permanent wilting point. Table (3) shows the values of the soil quality and health indices for the physical properties, as these values ranged between the first and second classes, while the third class did not appear among those classes, due to the fact that the study area is desert in which coarse-textured soils are common, which affects the rest of the physical and hydraulic characteristics of the soil such as the bulk density, porosity and hydraulic properties of soil, which was reflected on the types of soil health in the performance of its functions, as the percentage of the poor type from the total area of the project reached (12%), while it reached The percentage of the moderate variety (88%) of the total area of the project (figure 2), while the good variety did not appear as a soil health class because the study area was affected by its arid conditions, and the high sand content in most of the soil textures of the study had a strong impact on other physical characteristics, especially hydraulic This also confirmed by (20, 22) that the increase in sand content increases both the tip rate and the saturated and unsaturated water conductivity, as well as the increase in the values of bulk density and a clear decrease in the stability of the assemblies.

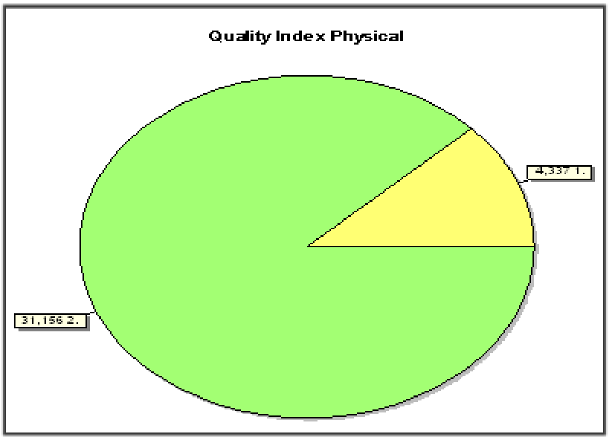

Figure 2. physical soil health class

Soil health and quality indices for biological characteristics: The soil health index was measured for biological characteristics, as the characteristics of vegetation cover, preparation of microorganisms, soil respiration, vegetation cover, and biomass were selected. Table (3) shows the values of the soil quality and health indices for the biological characteristics, as these values ranged between the first and second classes at a higher rate than the third class, due to the prevalence of arid conditions in the study area that affect the growth of organisms in general and affect the growth of microorganisms in particular. This is reflected in the varieties of soil health in the performance of its vital functions. Table (3) shows the emergence of three types of soil health in relation to the biological characteristics, the poor and moderate types were prevalent in the study area, as the percentage of the poor type of the total area of the project was (44%), while the percentage of the moderate variety reached (53%) of the total area for the project, the percentage of the good class was (3%) of the total area of the project (Figure 3).

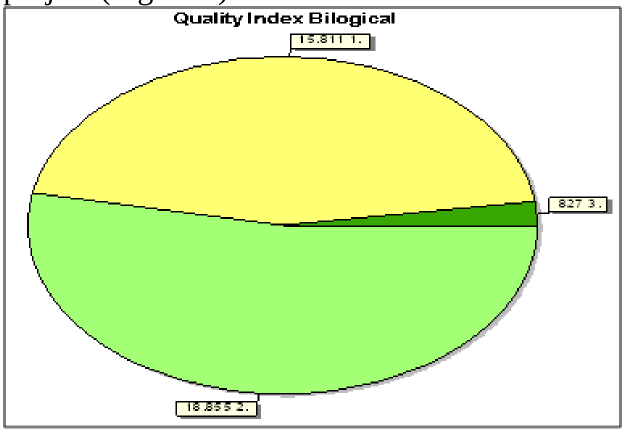

Figure 3. biological soil health class

After estimating the physical and biological characteristics of the soil and extracting the types of soil quality and health, all the traits were adopted in extracting the type of quality index and their validity in relation to the aforementioned properties combined, as the soil characteristics actually affect in an overlapping manner with each other, as the physical characteristics such as soil texture and apparent density affect the vital characteristics Clearly. Table (3) shows the types of soil quality in relation to the physical and biological characteristics combined with each other, as it is noted that the first and second types appear in common with the emergence of the third type in only two locations, and this is reflected in the soil health types that ranged between poor and moderate. The appearance of poor and moderate classes in a common way indicates the possibility of modifying these varieties to the good classes after preparing an approved management plan in the management of desert soils using the available means of soil management in the service of soil and plants, and since the main factor in soils in arid areas is the abundance of water, so the provision of water suitable for irrigation and the addition of enhancement reagents, as well as the cultivation of some hybrids tolerant of salinity, heat and drought, is one of the means of sustainability in the uses of desert soils.

Conclusions: From the previous results, the following can be concluded: The study area (Fadak farm) was characterized by the predominance of course and medium textures between sandy and mixed textures, with the emergence of some areas with sandy and clayey textures. The values of bulk density increased in the study area due to the high soil content of the separated sand as well as the low organic matter content in it. This was also reflected in the values of total porosity in the soil, which appeared at relatively low values in coarse-textured soils compared to medium-textured soils. The values of the mean weight diameter reflected low values, which indicates the weakness of the soil structure and the stability of the aggregation in the soils of the Fadak farm project. The values of soil infiltration rate increased in the study area due to the high content of coarse separated in its soil. This was also reflected in the saturated hydraulic conductivity values. The values of the penetration resistance of the roots showed relatively high values due to the high content of the coarse part. The effect of the sum of the physical and hydraulic properties of the soil on the limits of the field capacity and the permanent wilting point and consequently the content of ready water in the soil. Because of the difference in land use in the Fadak farm area, the vegetation coverage showed varying levels from one region to another, depending on the nature of the land use in each location. Also, the characteristic of soil respiration differed after measuring the concentration of carbon dioxide in the soil air according to the nature of the land use in it. Microbial communities (bacteria and fungi) showed low values throughout the study area, with a good content in the soils of the areas cultivated with jet and protected agriculture. The soil quality index for physical characteristics showed two types of soil quality, they are the first and second types, which correspond to the poor and moderate types in the approved soil health classification, where the moderate variety was dominant. Likewise, the case appeared in the classification of the soil quality index with regard to the chemical characteristics. Soils fell into two types of soil quality, the first and the second, which corresponded to the poor and moderate types in soil health, and the moderate type prevailed in it. Small areas showed good qualitative evidence for the vital traits with the emergence of the poor and moderate classes in these traits, as the dominance was also located for the second class in the quality index and the moderate class in its validity. In the overall physical and biological characteristics, the soil quality index showed two types prevalent in the study area, the first and second types.

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