The Soil Management Practices and Land Use Periods in Relation to Soil Health of Some Sandy Calcareous Soils in Egypt

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ABSTRACT: The current study was carried out to compare and analyze changes in soil health of some new reclaimed soils under different management practices (cropping patterns, irrigation systems and, water sources) and under different cultivation periods (0, 5, 20 and 50 years). The study area lies in the North West of the Nile Delta and includes parts of the West Beheria Settlement Project (WBSP) and some surrounding soils. It was chosen to represent the dominated calcareous sandy soils at that region. Soil health index relevant to the investigated soils was proposed, and relative soil health index (RSHI) was calculated. Data indicated that cultivated soils of the study area are generally characterized by intermediate to low relative soil health / quality index (RSHI) values ranging between 38.75 and 67.00 %. Data showed also that cultivation tended to improve the soil health. However, changes in relative soil health values (∆RSHI) due to cultivation were found to be wide (4.75 – 31.50 %) and this could be assigned to the variation in the crop pattern and management practices. Soils cultivated with vegetables and using Nile water as irrigation water have the relative highest values of ∆RSHI among the studied soils (26.0 and 31.5%) On the other hand, soil cultivated with fruits showed the relative lowest values of ∆RSHI (7.5 – 8.0%) in the soils using the same source of irrigation water (Nile water). Using Nile water caused a relative higher ∆RSHI value (26.0%) than using artesian water (4.75%) in soil cultivated with vegetables. Soils cultivated for 20 years and using either drip irrigation or flood irrigation by Nile water reveal very slight variation in values of ∆RSHI under the same crop pattern. However, data indicated that ∆RSHI values in the drip irrigated soils using Nile water tended to decrease as land use period increased, while the reverse occurred in soils using flood irrigation. Results obtained from the application of MicroLEIS software are, to a large extent, in harmony with those obtained from soil health studies using the relative soil health / quality index values (RSHI) and their changes (∆RSHI values) as well as the soil health / quality classes. However, it can be stated that MicroLEIS software can be used only at the regional scale, as it showed only the major differences in the land capability, while RSHI can be used successfully in small areas, which have minor differences.

Key words: soil health, Management practices, Calcareous sandy soils.

INTRODUCTION

New reclaimed soils in Egypt have their own problems and efforts have been directed towards raising their productivity. Soil changes are dynamic over time and productivity is related to the developed characteristics as a result of cultivation and management practices. Soil health is the capacity of soil to sustain and support growth of crops and animals while also maintaining the environment (Lal, 2011). It is an interaction of chemical, biological and physical properties as well as soil management practices (Lal, 2011).The terms soil quality and soil health are currently used interchangeably in the scientific literature and popular press. According to Pankhurst *et al*. (1997), the definition of soil quality proposed previously by Doran and Parkin (1994) is similar to that of soil health. However, they stated that the inclusion of a time component i.e.

'the continued capacity of' in the above soil health definition distinguish it from the definition of soil quality. In the same connection, Warkentin (1995) considered soil health as an integral to the concept of sustainable agriculture. He reported that soil health is the state of the soil at particular time, equivalent to the “dynamic” soil properties that change in the short term. On the other hand, soil quality is the soil usefulness for a particular purpose over a longer time scale, equivalent to “intrinsic” or “static” soil quality. Examples of dynamic soil properties are organic matter content, the number of diversity of organisms, and microbial constituent or products. In general, some scientists favor using the joint term soil quality / health or soil health / quality in the interest of promoting communication and developing an understanding of the language and methods used to manage soils (Harris and Bezdicek, 1994).

Agriculture practices coupled with poor management have been responsible for considerable land degradation. With the databases and soil health assessments, scientists should be able to predict soil behavior under various cropping systems and land uses. Moreover, it is important to predict the vulnerability of soils to degradation or to determine when soil health will be impaired in the long term (Miller and Wali, 1995). Thus, there is an urgent need to develop early-warning indicators to predict potential land degradation and identify the early stages of actual degradation, since the sustainable agriculture is based on maintenance and enhancement of the inherent soil health. A single soil characteristic is of limited use in evaluating differences in soil health and a minimum data set (MDS) of soil characteristics must be selected and quantified

The MDS recommended by Kennedy and Papendick (1995) includes organic matter, aggregation, and bulk density, depth to hardpan, electrical conductivity, fertility, respiration, pH, soil test, yield, infiltration, mineralizable nitrogen potential and water holding capacity. Fayed (2003) used organic matter, (clay + silt %), salt content, ESP, water table level and available N, available P, available K, available Fe, available Mn, available Zn and available Cu to calculate soil quality index in El-Bostan area. Because soil quality assessment is purpose- and site-specific, indicators used by different researchers or in different regions may not be the same. Abdelrazek (2014) used soil enzymes and macro elements to calculate soil health index in calcareous sandy soils in new reclaimed soil. Karlen *et al.* (1994) developed a soil quality index (QI) based on four soil functions: accommodating water entry (we), retaining and supplying water to plants (wt), resisting degradation (rd), and supporting plant growth (spg). After normalizing, each value is then multiplied by its weighting factor (wt) and products are summed as follow:
$QI = q_{\underline{we}}\,(wt) + q_{wt}\,(wt) + q_{rd}\,(wt) + q_{spg}\,(wt)$

The values of the index ranged between zero and one. Wang and Gong (1998) used a similar method of Karlen *et al.*(1994**)** and introduced a new concept namely relative soil quality index (RSQI). The equation for calculating RSQI value is:
$RSQI = (SQI / SQI_{m})*100$
Where SQI is soil quality index and SQI_{m} is the maximum value of SQI (at the most optimum conditions). Their selection of the soil quality indicators as well as

the weight of each indicator was based on the previous studies and the natural conditions of the studied area. According to Wang and Gong (1998), their method was found to be helpful for studying soil changes, soil degradation, evaluation of soil quality and sustainability at regional levels. The objectives of this work are to assess soil health status of the are lies in the North west of the Nile Delta including parts of the west Beheria settlement project which is about 3500 Feddans as affected by management practices and cultivation periods.

MATERIALS AND METHODS

The study area lies in the North West of the Nile Delta. It is located at the east of the main Cairo- Alexandria desert road between km 156 / 72 and km 160 / 68. It includes parts of the West Beheria Settlement Project (WBSP) and some surrounding soils. It is bounded to the West by the Cairo- Alexandria desert road, to the East and the North by the WBSP project soils, and to the South by the extended parts of Dalla and Ragab farms (Fig.1). The area under investigation is about 3500 feddan.

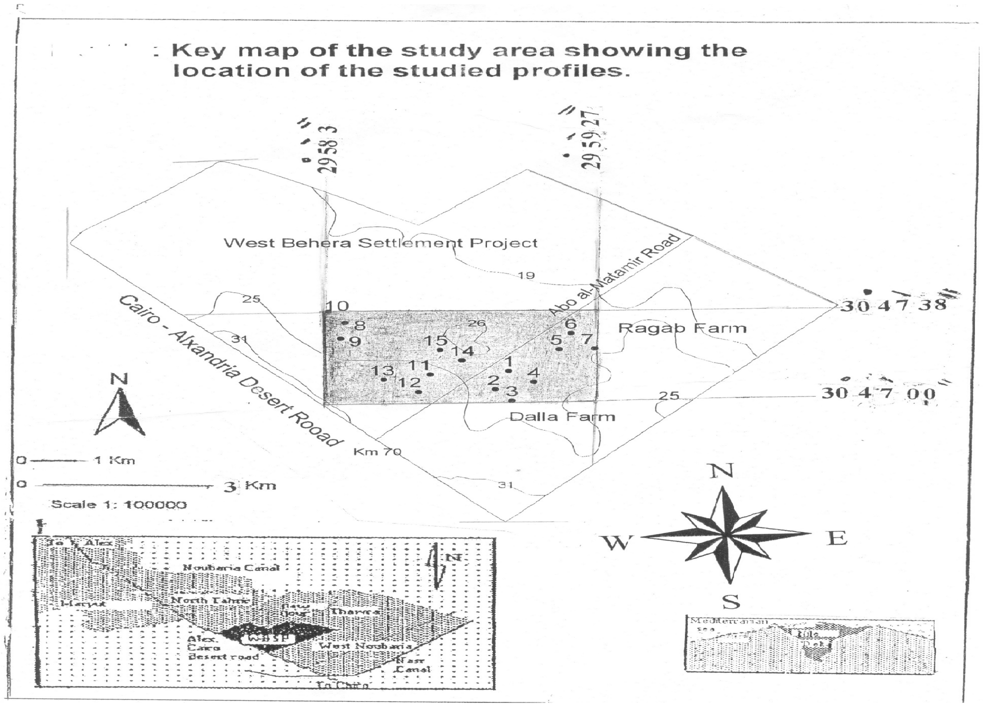

Fig. (1). Key map of the study area showing location of the studied profiles

Fifteen soil profiles were selected in the calcareous sandy soils Table (1) of the study area to represent variations in cropping patterns, irrigation methods and different irrigation water sources, Table (2) as well as different land use periods. The present cropping patterns include field crops (Corn and Peanut), vegetables (Tomato and Cucumber) and fruits (Guava, Grape and Apricot). Irrigation methods include flood and drip, whereas the sources of irrigation water were Nile water and artesian wells. The land use period represents 0 (non-cultivated), 5, 20 and 50 years.

Table (1). The soils texture, total Carbonate and Gypsum in the studied area

Profile No	Depth cm	$CaCO_3$ (%)	$CaSO_4$ (%)	Sand	Silt	Clay	Silt + Clay	Soil Texture
Virgin soil (control)								
1	0 - 30	10.30	0.00	86.5	0.7	12.8	13.5	Loamy sand
	30 - 45	11.05	0.00	86.6	1.4	12.0	13.4	Loamy sand
	45 - 75	10.50	0.00	85.9	1.2	12.9	14.1	Loamy sand
	75 - 120	9.45	0.00	85.9	1.1	13.0	14.1	Loamy sand
Soil cultivated with fruits for5 years- drip irrigation- artesian water.								
2	0 - 30	10.50	0.00	89.1	0.7	10.2	10.9	Loamy sand
	30 - 45	9.45	0.00	89.4	0.8	9.8	10.6	Loamy sand
	45 - 75	9.50	0.00	88.0	0.8	11.2	12.0	Loamy sand
	75 - 120	10.90	0.00	81.8	2.0	16.2	18.2	Loamy sand
Soil cultivated with vegetables for 5 years- drip irrigation- artesian water								
3	0 - 30	9.20	0.00	86.5	0.5	13.0	13.5	Loamy sand
	30 - 45	10.60	0.00	87.4	0.6	12.0	12.6	Loamy sand
	45 - 75	10.10	0.00	87.9	0.8	11.3	12.1	Loamy sand
	75 - 120	10.15	0.00	88.0	0.8	11.2	12.0	Loamy sand
Soil cultivated with field crops for 5 years- drip irrigation- artesian water.								
4	0 - 30	10.55	0.00	89.9	1.5	8.6	10.1	Loamy sand
	30 - 45	10.75	0.00	83.5	0.9	15.6	16.5	Loamy sand
	45 - 75	12.50	0.00	83.2	3.0	13.8	16.8	Loamy sand
	75 - 120	11.30	0.00	83.7	2.5	13.8	16.3	Loamy sand
Virgin soil (control)								
5	0 - 30	11.85	0.00	89.1	3.4	7.5	10.9	Loamy sand
	30 - 45	10.69	0.00	87.2	3.0	9.8	12.8	Loamy sand
	45 - 75	12.39	0.00	86.6	0.4	13.0	13.4	Loamy sand
	75 - 120	12.45	0.00	92.0	0.4	7.6	8.0	Loamy sand
Soil cultivated with vegetables for 5 years- drip irrigation- Nile water								
6	0 - 30	10.75	0.00	86.6	0.4	13.0	13.4	Loamy sand
	30 - 45	11.81	0.00	90.2	0.4	9.4	9.8	Loamy sand
	45 - 75	11.83	0.00	88.0	0.7	11.3	12.0	Loamy sand
	75 - 120	11.57	0.00	84.2	1.6	14.2	15.8	Loamy sand
Soil cultivated with fruits for 5 years- drip irrigation- Nile water.								
7	0 - 30	9.33	0.00	86.6	0.4	13.0	13.4	Loamy sand
	30 - 45	12.15	0.00	90.2	0.4	9.4	9.8	Loamy sand
	45 - 75	12.12	0.00	88.0	0.7	11.3	12.0	Loamy sand
	75 - 120	10.19	0.00	84.2	1.6	14.2	15.8	Loamy sand
Virgin soil (control)								
8	0 - 30	13.28	0.00	89.8	3.5	6.7	10.2	Loamy sand
	30 - 45	10.74	0.00	90.4	3.4	6.2	9.6	Loamy sand
	45 - 75	12.76	0.00	91.5	3.1	5.4	8.5	Loamy sand
	75 - 120	16.32	0.00	91.6	3.3	5.1	8.4	Loamy sand
Soil cultivated with fruits for 20 years- flood irrigation- Nile water								
9	0 - 30	11.59	0.00	89.7	1.2	9.1	10.3	Loamy sand
	30 - 45	12.27	0.00	89.8	1.1	9.1	10.2	Loamy sand
	45 - 75	12.23	0.00	83.0	1.0	16.0	17.0	Loamy sand
	75 - 120	13.78	0.00	83.3	1.2	15.5	16.7	Loamy sand
Soil cultivated with field crops for 20 years- flood irrigation- Nile water.								
10	0 - 30	10.64	0.00	92.2	0.2	7.6	7.8	Loamy sand
	30 - 45	10.64	0.00	90.4	0.4	9.2	9.6	Loamy sand
	45 - 75	10.67	0.00	88.0	0.7	11.3	12.0	Loamy sand
	75 - 120	14.68	0.00	82.9	0.5	16.6	17.1	Loamy sand
Virgin soil (control)								
11	0 - 30	19.95	0.48	86.2	3.8	10.1	13.8	Loamy sand
	30 - 45	19.05	0.26	78.7	11.3	10.0	21.3	Loamy sand
	45 - 75	22.09	0.25	82.7	3.8	13.5	17.3	Loamy sand
	75 - 120	20.33	0.15	83.7	6.3	10.0	16.3	Loamy sand

Soil cultivated with field crops for 20 years- drip irrigation- Nile water								
12	0 - 30	17.10	0.00	82.5	2.5	15.0	17.5	Loamy sand
	30 - 45	20.52	0.00	85.0	2.5	12.5	15.0	Loamy sand
	45 - 75	23.51	0.00	82.5	2.5	15.0	17.5	Loamy sand
	75 - 120	23.09	0.00	79.9	5.1	15.0	20.1	Loamy sand
Soil cultivated with fruits crops for 20 years- drip irrigation- Nile water.								
13	0 - 30	14.70	0.00	86.2	1.3	12.5	13.8	Loamy sand
	30 - 45	19.80	0.00	83.7	3.8	12.5	16.3	Loamy sand
	45 - 75	19.80	0.00	83.7	3.8	12.5	16.3	Loamy sand
	75 - 120	25.05	0.00	86.1	3.8	10.1	13.9	Loamy sand
Soil cultivated with field crops for 50 years- flood irrigation- Nile water.								
14	0 - 30	14.54	0.00	82.4	5.3	12.3	17.6	Loamy sand
	30 - 45	16.82	0.00	79.4	6.1	14.5	20.6	sandy Loam
	45 - 75	16.34	0.00	81.7	5.0	13.3	18.3	Loamy sand
	75 - 120	18.19	0.00	82.5	7.2	10.3	17.5	Loamy sand
Soil cultivated with vegetables for 50 years- flood irrigation- Nile water.								
15	0 - 30	13.21	0.00	84.4	4.3	11.3	15.6	Loamy sand
	30 - 45	10.64	0.00	79.9	5.1	15.0	20.1	sandy Loam
	45 - 75	14.03	0.00	82.8	5.0	12.2	17.2	Loamy sand
	75 - 120	19.29	0.00	81.7	7.0	11.3	18.3	Loamy sand

Clay % with calcium carbonate

Table (2). Chemical analysis and quality classes of irrigation water samples collected from the studied area

Irrigation water	pH	EC	Soluble cations and anions, me/L									Quality
Samples		ds/m	Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO4	SAR	classes
Nile water, branch No.1 Profiles No. (12 - 13)	7.90	0.61	1.19	0.13	1.64	1.56	0.00	2.80	2.91	0.50	0.94	C2 - S1
Nile water, branch No.2 Profiles No. (6 - 7)	7.80	0.52	1.20	0.12	1.99	1.20	0.00	2.65	1.72	0.48	0.95	C2 - S1
Nile water, branch No.3 Profiles No. (14 - 15)	7.70	0.62	1.34	0.15	2.86	1.13	0.00	2.80	1.82	0.81	0.96	C2 - S1
Nile water, branch No.4 Profiles No. (9 - 10)	7.51	0.88	1.29	0.16	2.34	1.14	0.00	2.90	1.72	0.91	0.99	C3 - S1
Well No.1 Profiles No. (2)	8.52	1.33	7.10	0.15	1.90	1.88	1.90	5.10	3.82	2.42	5.02	C3 - S2
Well No.2 Profiles No. (3 - 4)	8.81	2.92	18.40	0.15	5.10	5.82	1.70	2.50	14.90	14.03	7.86	C4 - S2

C1: low salinity C2: medium salinity C3: high salinity C4: very high salinity
S1: low alkalinity S2: medium alkalinity S3: high alkalinity S4: very high alkalinity

Profiles No 1, 5.8 and 11 are virgin soils without irrigation sources

Soil health

1. Selection of soil health indicators.

Based on soil health concept and according to the previous studies on the investigated area and the adjacent areas, 14 soil indicators were selected in this study. They include organic matter content (%), fine fractions (clay + silt) %, microbial biomass (C mg g^{-1}), salt content (dSm^{-1}), soil reaction (pH), SAR, available N (mg kg^{-1}), available P (mg kg^{-1}), available K (mg kg^{-1}), available Fe (mg kg^{-1}), available Mn (mg kg^{-1}), available Zn (mg kg^{-1}) and available Cu (mg kg^{-1}) of the surface horizon, as well as water table level in the studied soil profiles. The usual soil chemical analysis was carried out according to Jackson (1958). Microbial biomass was determined using soil fumigation method, as described by Parkinson and Paul (1982). Available nitrogen was extracted using

2M KCl and determined by the micro-kjeldahl method, while available potassium was carried out by flame photometer using the ammonium acetate method (Black, 1965). Available phosphorus was determined using sodium bicarbonate, as an extracting agent, according to Olson and Watanabe (1965). The micronutrients Fe, Mn, Zn and Cu were extracted using DTPA, as recommended by Lindsay and Norvell (1978) and determined using Atomic Absorption Spectrophotometer.

The above properties reflect the suitability of soil physical, chemical and biological conditions for sustainable land use as well as the nutrient status of the soil for plant growth. They also reflect the role of soil in regulating and partitioning water and solute flow. Moreover, they emphasize the importance of the soil biota in soil functioning and include most of the dynamic soil properties that are easily degraded by poor soil management. However, the above selected soil indicators include some of the relatively static or intrinsic properties (e.g. contents of fine fractions and level of water table) that require a longer time for change. Since the terms soil quality and soil health are currently used interchangeably in the scientific literature (Harris and Bezdicek, 1994), and assessment of soil quality could serve as an assessment of soil health to a large extent (Pankhurst *et al*., 1997), it is better to use the term soil health / quality (SHQ) in the present study rather than to use the term soil health.

2. Rating of soil health indicators

Soil health indicators were rated into four classes (I, II, III and IV). Class I is the most suitable for plant growth, class II reflects moderate suitability for plant growth with slight limitations, class III indicates presence of more serious limitation than class II, and class IV represents the severe limitations for plant growth Table (3). The range of each class is shown in Table (1). Because soil health assessment is purpose- and site-specific, the rating of each class was based on the research knowledge of the calcareous sandy soils under similar conditions taking into consideration to what extent could the calcareous sandy soils improve under the optimum conditions (Reda, 1963; Abu-Zayed, 1973; Badawi, 1976; El-Sawaby and Abu-El-Anine, 1977; Metwally, 1978; Abd-El-Hadi *et al*., 1986; Rabie *et al*., 1988; Fayed, 2003; Fayed *et al*., 2005). Marks of 4, 3, 2, and 1 were given to classes I, II, III and IV, respectively.

Table (3). Five soil health / quality classes were suggested to describe the soil health

Classes	RSHI value
I	100-85 best
II	<85 – 75
III	<75 – 65
IV	<65 – 50
V	<50 worst

3. Weights of soil health indicators

The contribution or importance of each indicator to soil health (SH) is usually different and can be indicated by a weighting coefficient. There are many ways to assign the weight of each indicator. This includes experience, mathematical statistics or models (Wang and Gong, 1998). In this study, the weight of each indicator Table (4) has been assigned on the basis of previous research work and experience under Egyptian conditions. The sum of all weights was normalized to 100%.

4. Quantitative evaluation of changes in soil health

The selected soil indicators of each surface horizon as well as the water table level in the studied soil profiles were combined into a single value namely soil health index (SHI) using the following equation (Karlen *et al*., 1994):

$$\text{SHI} = \sum W_i \quad I_i$$

Where (W_I) are the weight of each indicator and (I_i) are the marks of the indicator classes. Using the above equation, SHI for every indicator can be calculated and the SHQI value for a soil can be produced by summing up its 14 indicators- SHI values. Naturally the maximum value of SHI for the soil is 400 and the minimum value is 100.

The relative soil health index (RSHI) was calculated according to the method proposed by Wang and Gong (1998) using the following equation:

$\text{RSHI} = (\text{SHI} / \text{SHI}_m) *100$

Where SHI is soil health index and SHI_m is the maximum value of SHI (at the most optimum conditions).

An optimal soil will have a normalized RSHI of 100, but real soils will have lower values, which indicate directly their distance from the optimal soil. Based on Wang and Gong (1998) and Fayed (2003), five soil health classes were suggested to describe the soil health, as shown in the following:

Table (4). Soil health indicators and their weights and classes for the evaluation of soil health in the study area

Indicators	Weight	Class I	Class II	Class III	Class IV
Organic matter %	10	> 1.5	1.0 – 1.5	0.5 - 1.0	< 0.5
(clay + silt) %	10	> 20	15 - 20	14.9 – 10	< 10
Salinity (EC dSm^{-1})	10	< 1.5	1.5 – 4.0	4.1- 8.0	> 8.0
SAR	10	< 5.0	5.0 – 8.0	8.1- 13	> 13
pH	10	7.0 - 7.5	7.5 – 8.0	8.1- 8.5	> 8.5
Water table level(cm)	10	> 150	125 –150	100 -124	< 100
Microbial biomass (mg C/g)	10	> 0.7	0.7 – 0.4	0.39–0.2	< 0.2
Available N (mg/kg)	6	> 80	40 – 80	20 – 39	< 20
Available P (mg/kg)	6	> 15	10 – 15	5 – 9.9	<5
Available K (mg/kg)	6	> 400	200 -400	100 – 199	< 100
Available Fe (mg/kg)	3	> 4.0	3.0 – 4.0	2.0 – 2.9	< 2.0
Available Mn (mg/kg)	3	> 1.5	1.25 -1.50	1.0 – 1.24	< 1.0
Available Zn (mg/kg)	3	> 1.5	1.25-1.50	1.0 – 1.24	< 1.0
Available Cu (mg/kg)	3	> 0.5	0.4-0.5	0.2 – 0.39	< 0.2

By computing RSHI values, soil health in different profiles representing different land use periods and management practices can be compared. Similarly, the change in RSHI (∆RSHI) could quantify changes in soil health under different conditions. Changes in RSHI (∆RSHI) values were calculated as follows:

∆ RSHI = RSHI (cultivated) – RSHI (virgin).

5. Land evaluation

Recently, a computer program namely Microcomputer-based Land Evaluation Information System (MicroLEIS) was developed to evaluate the soils of the Mediterranean region and satisfy the requirements of the FAO land evaluation system (De La Rosa *et al*., 1992). It was designed and constructed using a sequence of programs (CERVATANA and ALMAGRA programs (Fayed *et al*., 2005) for assessing general land capability and agricultural soil suitability, respectively). MicroLEIS have several INFO files from which each program is assessed. The used computer programs within MicroLEIS have been developed using BASIC programming language and run on an IBM PC with at least 128 kilobytes of RAM. They were used for assessing changes in general land capability and agricultural soil suitability in the study area and comparing the obtained results with values of RSHI.

RESULTS AND DISCUSSION

Data presented in Tables (5 and 6) indicate that the cultivated soils are generally characterized by intermediate to low relative soil health index (RSHI) values ranging between 38.75 and 67.00 %. Data show also that soil profiles representing cultivated soils have higher RSHI values than those representing virgin soils (33.75 – 48.00 %). This means that cultivation tends to improve the soil health. Also, changes in relative soil health / quality values (∆RSHI) due to cultivation were found to be wide (4.75 – 31.50 %). This could be assigned to the variation in the crop pattern and management practices.

Regarding the effect of crop pattern on RSHI values, data presented in Table (6) show that soils cultivated with vegetables using Nile water as irrigation water (profiles 6 and 15) have the relative highest values of ∆RSHI among the studied soils (26.0 and 31.5%, respectively). This may be due to the relative higher application of fertilizers and manures to the soils cultivated with vegetables, as well as their intensive surface root system, which can lead to increasing organic matter content, fine fractions and most of the available nutrients, as shown in Table (5). On the other hand, fruits show the relative lowest values of ∆ RSHI (7.5 – 8.0%) in the soils using Nile water as irrigation water (profiles 9 and 13). This may be due to their root system nature as well as the relative lower application of fertilizers and manures in case of fruits cultivation, which results in lowering their RSHI values and subsequently their ∆RSHI values.

Table (5). Scores of soil health indicators in the studied soils

Profile	Cropping	Source of	Method	The weights of the indicators * The marks of the indicators classes (W_i * I_i).														
No.	pattern	irrigation water	of irrigation	O.M.	Clay+ silt	EC	SAR	pH	W.t depth	Microbial biomass	Avail N	Avail P	Avail K	Avail Fe	Avail Mn	Avail Cu	Avail Zn	SHI
									Soils cultivated for 5 years									
1	Virgin			10	20	20	10	10	20	10	6	6	12	3	3	3	3	136
2	Fruits	Artesian*	Drip	20	20	30	20	10	30	20	6	6	6	3	3	3	3	180
3	Vegetables	Artesian**	Drip	10	20	10	10	10	30	20	6	6	12	3	12	3	3	155
4	Field crops	Artesian**	Drip	10	20	20	10	30	30	10	6	12	6	3	12	3	3	175
5	Virgin		Drip	10	20	10	10	10	20	10	6	6	12	3	3	12	3	135
6	Vegetables	Nile water	Drip	20	20	20	20	30	30	30	6	12	12	12	12	12	3	239
7	Fruits	Nile water	Drip	10	20	20	20	20	30	20	6	6	6	3	12	3	3	179
									Soils cultivated for 20 years									
8	Virgin			20	20	30	20	10	30	20	6	6	12	3	6	6	3	192
9	Fruits	Nile water	Flood	20	20	40	30	10	30	20	12	6	12	6	12	3	3	224
10	Field crops	Nile water	Flood	20	10	40	30	30	30	30	12	6	12	3	12	12	3	250
11	Virgin			10	20	10	10	20	20	10	6	6	12	3	3	9	3	142
12	Field crops	Nile water	Drip	10	30	20	10	30	20	40	18	6	6	3	3	3	3	202
13	Fruits	Nile water	Drip	20	20	20	10	20	20	20	12	12	6	3	3	3	3	172
									Soils cultivated for 50 years									
14	Field crops	Nile water	Flood	20	30	30	20	30	10	20	12	6	6	3	12	12	3	214
15	Vegetables	Nile water	Flood	20	30	40	30	30	10	30	18	12	18	3	12	12	3	268

* Quality class is C3 - S2.

** Quality class is C4 - S2.

Concerning the effect of irrigation water source on the values of ∆RSHI, data presented in Table (6) and illustrated in Fig.(2) indicate that using Nile water caused a relative higher ∆RSHI value (26.0%) than using artesian water (4.75%) in the soils cultivated with vegetables for 5 years and represented by profiles 6 and 3, respectively. This could be due to the relative lower EC and SAR values in Nile water than artesian water, while the similar ∆RSHI value (11.0%), which was obtained in soils cultivated with fruits for the same land use period using Nile water and artesian water (profiles 7 and 2, respectively), may be due to using a relative higher quality class of artesian water (Table 6) having a relative lower salinity than other source of artesian water. Moreover, the root system of fruits, being deeper and less extensive, enhances water movement and salt leaching to relatively deeper horizons.

As for the effect of the two methods of irrigation, data presented in Table (6) and illustrated in Fig.(3) indicate that variation in ∆RSHI values in case of soils cultivated for 20 years using either drip irrigation or flood irrigation method and Nile water as a source of irrigation water was very slight under the same crop pattern. It was 15.0 and 14.5% in profiles 12 and 10, which represent soils cultivated with field crops using drip irrigation and flood irrigation, respectively, while in case of fruits cultivated soils it was 7.5 and 8.0%, respectively (profiles 13 and 9).

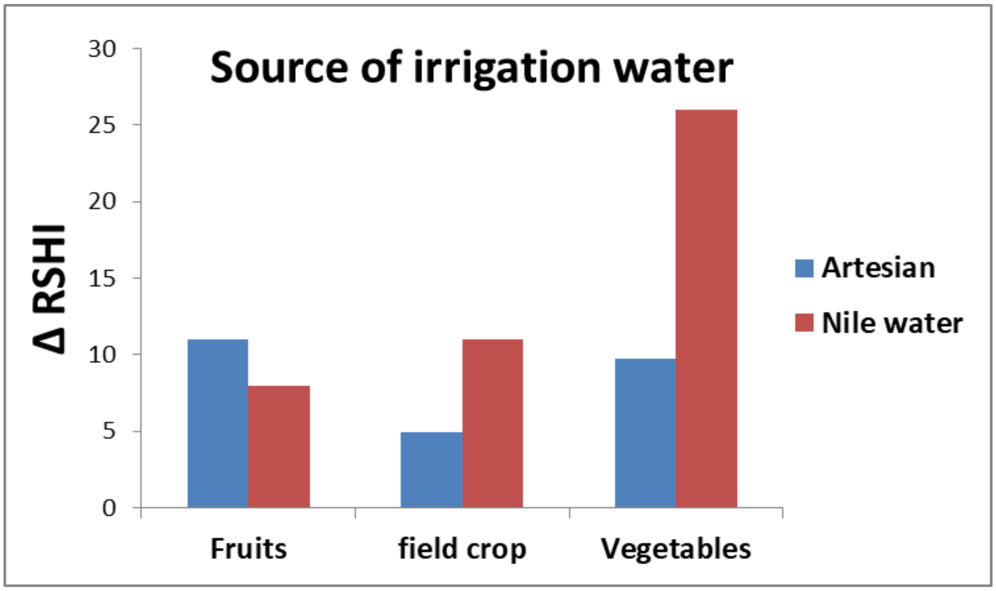

Fig (2). Effect of irrigation water source on ∆RSHI values in soils cultivated for 5 years

In spite of the above slight variation in ∆RSHI values in soils cultivated for 20 years using Nile water and either drip or flood irrigation method, and taking into consideration the effect of land use period on ∆RSHI values, data presented in Table (6) and illustrated in Fig. (3) show that ∆RSHI value in the drip irrigated soils using Nile water tended to decrease as land use period increased. It decreased from 11.0 to 7.5% in the fruits cultivated soils (profiles 7 and 13), which represent soils cultivated for 5 and 20 years, respectively. Also, it decreased from 26% in soils cultivated with vegetables for 5 years (profile 6) to 15% in soils cultivated with field crops for 20 years (profile 12). The data presented in Table (5) indicate that the obtained lower values of ∆RSHI with increasing land use period in such soils were due to the increase in SAR values as well as the presence of available micronutrients in low amounts. Increase in SAR values may be due to the shallow penetration of dripped water, while its frequent use results in activation of carbonates which depresses the availability of micronutrients.

Table (6). Relative soil health index (RSHI), factor changes in relative soil health (∆RSHI) and their classes in the studied profiles as affected by the tested factors

Profile No.	Cropping pattern	Source of irrigation water	Method of irrigation	SHI	RSHI	RSHI classes	RSHI∆	∆RSHI/ year
Soils cultivated for 5 years								
1	Non.	Non.	Non.	136	34.00	V		
2	Fruits	Artesian*	Drip	180	45.00	V	11.00	2.20
3	Vegetables	Artesian**	Drip	155	38.75	V	4.75	0.95
4	field crops	Artesian**	Drip	175	43.75	V	9.75	1.95
5	Non.	Non.	Non.	135	33.75	V		
6	Vegetables	Nile water	Drip	239	59.75	IV	26.00	5.20
7	Fruits	Nile water	Drip	179	44.75	V	11.00	2.20
Soils cultivated for 20 years								
8	Non.	Non.	Non.	192	48.00	V		
9	Fruits	Nile water	Flood irrigation	224	56.00	IV	8.00	0.40
10	field crops	Nile water	Flood irrigation	250	62.50	IV	14.50	0.73
11	Non.	Non.	Non.	142	35.50	V		
12	field crops	Nile water	Drip	202	50.50	IV	15.00	0.75
13	Fruits	Nile water	Drip	172	43.00	V	7.50	0.38
Soils cultivated for 50 years								
11	Non.	Non.	Non.	142	35.50	V		
14	field crops	Nile water	Flood irrigation	214	53.50	IV	18.00	0.36
15	Vegetables	Nile water	Flood irrigation	268	67.00	III	31.50	0.63

* Quality class is C3 S2.

** Quality class is C4 -S2.

On the other hand, an opposite trend is observed in soils using flood irrigation method, where ∆RSHI value increased as land use period increased. The values increased from 14.5 to 18.0% in soils cultivated with field crops for 20 and 50 years, respectively (profiles 10 and 14) and reached its maximum value (31.5%) under the study conditions in the soil cultivated with vegetables (profile 15), as shown in Table (6). The obtained higher values of ∆RSHI in case of using flood irrigation with increasing land use period up to 50 years were due to the relative increase of organic matter, fine fractions, microbial biomass and available nutrients, as shown in Table (5).

The relation between ∆RSHI values and land use periods (5, 20 and 50 years) indicates that there is a wide variation in such values within each land use period. In this context, values of ∆ RSHI ranged from 4.75 to 26.00, 7.50 to 15.00 and 18.00 to 31.50% in soil cultivated for 5, 20 and 50 years, respectively, as shown in Table (6). This indicates that ∆ RSHI values are mainly governed by variations in crop patterns and management practices rather than land use periods. However, it was also found that rate of ∆RSHI per year decreased with increasing cultivation period. It ranged from 0.95 – 5.20, 0.38 – 0.75 and 0.36 – 0.63% in soils cultivated for 5, 20 and 50 years, respectively. This means that the rate of development of these soils is relatively higher at the beginning of reclamation and cultivation. Similar values were obtained by Fayed *et al*. (2005).

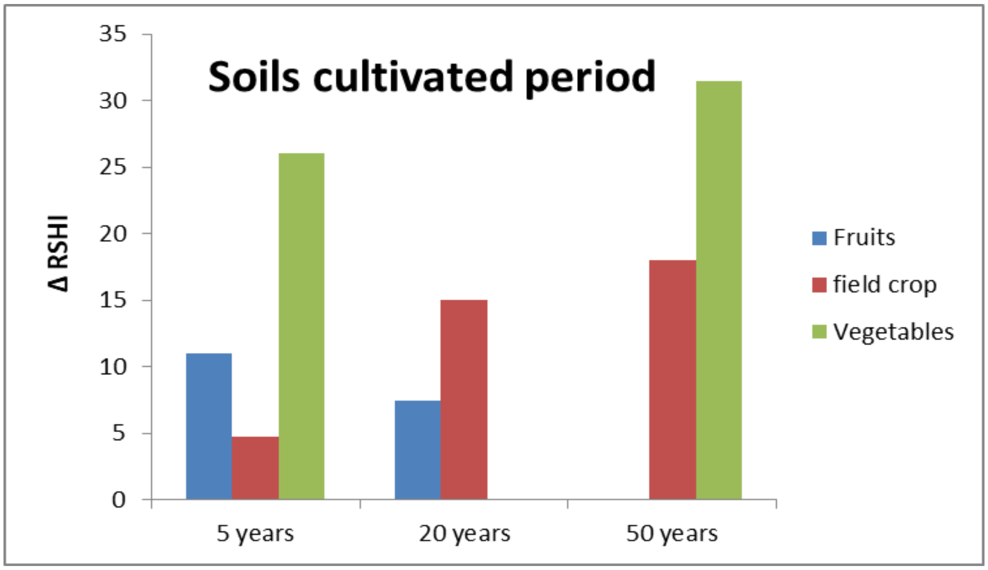

Fig (3). Effect of land use period on ΔRSHI values in soils irrigated with Nile water

Concerning the effect of cultivation on soil health classes in the study area, data indicate that it improved most of the soils using Nile water as irrigation water (profiles 6, 7, 9, 10, 12, 14 and 15), as shown in Table (6). The best soil health class in the study area is class III and it characterized only for soil cultivated with vegetables for 50 years, irrigated by Nile water and using flood irrigation method (profile 15). It was also found that most of the cultivated soils in the studied area have low soil health soil class (class IV), while those representing drip irrigated soils using artesian water as irrigation water as well as fruits cultivated soils using Nile water and drip irrigation have the worst soil health class (V). Such low soil health classes are mainly due to the low fertility status as well as unfavorable chemical and physical characters, as stated before. Even the mentioned soil having a relative higher class (III) is characterized by a higher water table reaching 80 cm from the soil surface.

On the light of the above results, it can be concluded that the studied soils could be improved by better management practices through careful addition of organic manures, better balanced fertilization, rotation with green manures and legumes and avoiding irrigation with low quality water as well as construction of an efficient drainage system.

Effect of management practices on Land evaluation classes

1. Land capability

Evaluation results from the application of the CERVATANA program within MicroLEIS on the study area indicate that the capability of all cultivated soils belongs to class 2, which means good capability. The exception case is profile 3 (has capability class 3), which represents soils cultivated with vegetables for 5 years using drip irrigation method and artesian water. Moreover, profiles representing virgin soils (profiles 1, 5, 8 and 11) exhibit different capability classes ranging from N to C2 (from marginal to good). This means that in most cases cultivation resulted in improving land capability classes, as shown in Table (7).

Data presented in Table (4) show also that there are three land capability subclasses (C3l, C2l and Nl) in the study area. This indicates that the main limiting factor is related to soil (De La Rosa *et al.*, 1992).

2. Soil suitability

Data of soil suitability classes and subclasses resulted from the application of the ALMAGRA program within MicroLEIS on the study area are presented in Table (4). These data show that most of the cultivated soils are moderately suitable (class3) for the tested field crops and vegetables. Also, some areas were found to be highly suitable (class 2) for fruits (profiles 2, 9, 10, 14, and 15), which represent flood irrigated soils by Nile water and a soil using a good quality of artesian water and drip irrigation (profile 2). On the other hand, most drip irrigated soils using Nile water (profiles 6, 7 and 12) exhibit moderate suitability (class 3) for fruits.

Regarding the subclasses, data show that the main limiting soil property in all the studied soils is soil texture (t). As mentioned before, the coarse texture of the studied soils, which is loamy sand, affects negatively soil qualities, especially those related to water availability and available nutrients. Also, sodium saturation (a), salinity (s), useful depth (p), and carbonate content (c) were found to be among the limiting factors, as shown in Table (4).

Concerning the effect of cultivation on the soil suitability, data indicate that cultivation tends to improve slightly the suitability classes and such effect increases as land use period increases. In this respect, data show that cultivation for 50 years resulted in improving soil suitability class from S5 (Very low) to S3 (Moderate), as shown in Table (7). In general, improvement in soil suitability may be due to the removal of salinity (s) and / or sodicity (a), as shown in the subclasses Table (7).

The above results are, to a large extent, in harmony with those obtained from soil health studies Fayed (2003) using the relative soil health index values (RSHI) and their changes (∆RSHI values) as well as the soil health classes. However, It can be stated that MicroLEIS software can be used only at the regional scale, as it showed only the major differences in the land capability, while RSHI can be used successfully in small areas, which have minor differences.

Table (7). Land capability and soil suitability classes of the investigated soils using MicroLEIS software

Profile	Land capability	Soil suitability classes*											
No.	classes*	Wheat	Corn	Melon	Potato	Soybean	Cotton	Sunflower	Sugar-beet	Alfalfa	Peach	Citrus	Olive
Soils cultivated for 5 years													
1	C3l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3s	S3s	S3s
2	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdca	S2tdca	S2tda
3	C3l	S4s	S4s	S4s	S4s	S4s	S4s	S4s	S4ts	S4ts	S5s	S5s	S3s
4	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3s	S3s	S3s
5	C3l	S4sa	S4sa	S4sa	S4sa	S4sa	S4sa	S4sa	S4a	S4a	S5s	S5s	S4a
6	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3s	S3s	S3s
7	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3s	S3s	S3s
Soils cultivated for 20 years													
8	C2l	S3ta	S4a	S3ta	S3ta	S3ta	S3ta	S3ta	S3ta	S3ta	S3a	S3a	S3a
9	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdca	S2tdca	S2tda
10	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdc	S2tdc	S2td
11	Nl	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s
12	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3s	S3s	S3s
13	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3ts	S4s	S4s	S3s
Soils cultivated for 50 years													
11	N	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s	S5s
14	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2ptdcs	S2ptdcs	S2ptds
15	C2l	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2ptdcs	S2ptdcs	S2ptda

Land capability classes*: C1=Excellent, C2= Good, C3= Moderate, N= Marginal
Limitations: l = soil is a limiting factor.
Soil suitability classes*:S1= non, S2= Slight, S3= Moderate, S4= Severe, S5= Very severe.
Limitations: p= useful depth, t= texture, d= drainage, c= carbonate (total), s= salinity, a= ESP

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REFERENCES

Abdelrazek, S. A. E. (2014). Effect of Wastewater Irrigation on Plant Enzymes and Soil Health Assessment in Borg Elarab Region , ph.D A thesis University of Sadat City

Abd-El-Hadi, A.H., A.M. El-Saadani., M.H. Rabie and A.A. Moustafa. (1986). Studies on soil fertility and productivity in sandy soils of Ismaelia Governorate. Conference on Land Improvement, Development of Reclamation in Egypt, Cairo, November 1986, Paper No.20

Abu-Zayed, I.S. (1973). Studies on improvement of some physical and chemical properties of calcareous soils. M. Sc. Thesis, Fac. of Agric., Ain Shams Univ., Egypt.

Badawi, A.M. (1976). Improvement of sandy and sandy calcareous soils in the A.R.E. Ph. D. Thesis, Fac. Agric., Cairo Univ., Egypt.

Black, C.A. (1965). Methods of Soil Analysis. Part 2. Agron. Monograph No.9, ASA, Madison, Wisc., USA.

De La Rosa, D., L.V. Moreno., J.A. Garcia and A. Almorza. (1992). MicroLEIS: A microcomputer-based Mediterranean Land Evaluation Information System. Soil Use and Management, 8: 89-96.

Doran., J.W. and T.B. Parkin (1994). Defining soil quality for a sustainable environment. In J.W. Doran, D.C. Coleman, D.F. Bezdicek, and B.A. Stewart (ed.). Defining Soil Quality for a Sustainable Environment. Soil Sci. Soc. Am . Spec. Pub. 35, Soil Science Society of America, Madison, WI.

Doran., J.W. and M. Safley. (1997). Defining and assessing soil health and sustainable productivity. In C. Pankhurst, B.M. Doube and V.V.S.R. Gupta (ed). Biological indicators of soil health. CAB International, Walingford, UK.

El- Sawaby, M. Sh. and A.A. Abu- El- Anine. (1977). Effect of quality of irrigation water on the chemical properties of the soils. Agric. Res. Rev., 55: 11-15

Fathi, A., M. Naga .,M.F. Kandil and M. el-Abbaseri. (1971) . Effect of land use period on soil properties. U.A.R. J. Soil Sci. 11 (2): 147-157.

Fayed, R.I.M. (2003). Impact of land management practices on soil quality in sandy soils, El-Bostan region- Egypt. Ph. D. Thesis, Alex. Fac. of Agric., Univ., Egypt.

Fayed, R ., E.M. El-Zahaby., A.M. El-Saadani and M.H. Bahnassy. (2005). Land quality, capability and suitability changes as influenced by management practices in El-Bostan area, A.R.E. Alex. J. Agric. Res., 50 (1): 169- 180.

Harris, R.F. and D.F. Bezdicek. (1994). Descriptive aspects of soil quality / health. In J.W. Doran, D.C. Coleman, D.F. Bezdicek, and B.A. Stewart (ed). Soil Sci. Soc. Am . Spec. Pub. 35, Soil Science Society of America, Madison, WI.

Jackson, M. L. (1958). Soil Chemical Analysis. Prentice Hall, Englwood Cliffs, N. J., USA.

Karlen, D.L., N.C. Wollenhaupt., D.C Erbach., E.C Berry., J.B Swan., N.S. Eash, and J.L. Jordahl. (1994). Crop residue effects on soil quality following 10-years of no-till corn. Soil Tillage Res., 31: 149- 167.

Kennedy, A.C. and R.I. Papendick. (1995). Microbial characteristics of soil quality. J. Soil Water Conserv., 50 : 243- 248.

Lal,R.(2011). Soil health and climate change: an overview,pp.3-24. In B.P.Singh, A.Cowie and K.Cham (eds). Soil health and climate change. Soil Biology 29. Springer Verlag, Berlin and Heidelberg.

Lindsay, W. and W. Norvell. (1978). Development of DTPA test for Zn, Fe, Mn and Cu. Soil Sci. Amer. J., 42: 421 – 427.

Metwally, S.Y.(1978). Methods used for increasing fertility of sandy soils. Egypt. J. Soil Sci. (Special Issue), pp. 41- 47.

Miller, F. P. and M. K. Wali. (1995). Soils, land use and sustainable agriculture: A review. Can. J. Soil Sci., 75: 413-422.

Olson, S.R. and F.S. Watanabe. (1965). Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. Soil Sci. Soc. Am. Proc., 29: 677 – 678.

Pankhurst, C.E., B.M. Doube and V.V.S. R.Gupta.(1997). Biological Indicators of Soil Health: Synthesis. In C. Pankhurst, B.M. Doube and V.V.S.R. Gupta (ed). Biological indicators of soil health. CAB International, Walingford, UK.

Parkinson, D. and E.A. Paul.(1982). Microbial Biomass. In Page, A.L. Methods of Soil Analysis. Chemical and Microbiological properties. 2nd. Edition. Soil Sci. Soc. Of America, Inc. Publisher, Madison, Wisconsin, USA.

Rabie, F., A.S. Sheta, and O.El- Sharif.(1988). Anthropic influences on the properties of some sandy soils in Egypt. Egypt J. Soil Sci. 28(2): 153-165.

Reda, F.(1963). A study on the development of calcareous soils of the Northern region of Tahrir Province during reclamation. M. Sc. Thesis, Fac. of Agric., Cairo Univ., Cairo, Egypt.

Wang, X. and Z. Gong.(1998). Assessment and analysis of soil quality changes after eleven years of reclamation in subtropical China. Geoderma, 81: 339- 355.

Warkentin, B.P.(1995). The changing concept of soil quality. J. Soil Water Coserv. 50: 226- 228.

الملخص العربي

أساليب إدارة التربة وفترات الاستخدام وعلاقتهما بصحة التربة لبعض الأراضي الرملية الجيرية بمصر

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أجريت هذه الدراسة بهدف تفسير ومقارنة التغيرات التي تطرأ على بعض خصائص الأراضي الرملية الجيرية الحديثة الاستصلاح وكذلك صحتها وذلك تحت تأثير مدة استخدام مختلفة (صفر، ٥، ٢٠، ٥٠ عاما) وأساليب خدمة مختلفة (نظم محصولية مختلفة، طرق ري مختلفة، ومصادر مياه للري مختلفة). وتقع منطقة الدراسة في الشمال الغربي من دلتا النيل وهى تشمل أجزاء من مشروع غرب البحيرة للتوطين وبعض الأراضي المجاورة لها. وقد تم اختيار هذه المنطقة لتمثل الأراضي الرملية الجيرية السائدة في هذا الإقليم. والهدف من هذه الدراسة هو تفهم تغيرات التربة والاستفادة من ذلك في الاستغلال الأمثل لهذه الأراضي، والعمل على تحسين خواصها وصحتها ، هذا وقد تم اقتراح دليل مناسب يعبر عن صحة وجودة هذه الأراضي .

وقد تميزت منطقة الدراسة بأن معظم الأراضي المنزرعة ذات صحة منخفضة الى متوسطة حيث تراوحت قيمة الدليل النسبي لصحة التربة (RSHI) الى ما بين ٣٨ – ٦٧% ، وقد أدت الزراعة الى ارتفاع قيم (RSHI) في الأراضي المنزرعة بالمقارنة بالأراضي البكر حيث تراوحت قيم الزيادة (ΔRSHI) ما بين ٤.٧٥ الى ٣١.٥٠% ، وهذه التغيرات ترجع الى تأثير كلا من نوعية المحصول والعمليات الزراعية.

وقد دلت النتائج على أن الأراضي المنزرعة بالخضر وتستخدم مياه النيل تمتلك أعلى القيم النسبية من(ΔRSHI) بين الأراضي المدروسة ، وعلى الجانب الآخر فقد أظهرت الأراضي المنزرعة فاكهة وتستخدم مياه النيل أقل القيم من(ΔRSHI). كما دلت النتائج على أن الأرض المنزرعة بالخضر وتستخدم مياه النيل تميزت بقيمة (ΔRSHI) أعلى من تلك التي تستخدم المياه الارتوازية ، و بينت النتائج أيضا أن الأراضي المنزرعة لمدة ٢٠ عاما والتي تستخدم مياه النيل وطريقة الري بالتنقيط أو الغمر تظهر تغيرات طفيفة جدا في قيم(ΔRSHI). وبالرغم من هذا وعند أخذ تأثير مدة استخدام الأرض في الاعتبار فقد وجد أن قيمة (ΔRSHI) في الأراضي التي تستخدم طريقة الري بالتنقيط تميل الى أن تنخفض بزيادة فترة استخدام الأرض. بينما أظهرت الأراضي التي تستخدم الري بالغمر اتجاها معاكسا.

كما أظهرت النتائج المتحصل عليها من تطبيق برنامج MicroLEIS توافقا لدرجة كبيرة مع نتائج دراسات صحة التربة باستخدام الدليل النسبي لصحة التربة ومدى تغير قيمته ، غير أنه يمكن القول أن هذا الدليل يمكن استخدامه بنجاح حيث يتميز بكمية أقل من المدخلات كما أنه يوضح الاختلافات الصغيرة في المناطق المحدودة.

كلمات دلالية: صحة التربة، أساليب الزراعة ، الأراضي الرملية الجيرية