Soil assessment for agricultural uses: Case study, selected localities from Wadi Feiran basin, Southwestern Sinai, Egypt

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ABSTRACT
Wadi Feiran basin lies at the southwestern part of Sinai Peninsula. The considered mega drainage pattern mainly granitic, volcanic, metamorphic, and sedimentary country rocks. The present work aims to study a numbers of parameters to evaluate the soil of Wadi Feiran for agriculture purposes. To achieve this study, thirteen soil profiles and twenty-five water samples were collected during Jan., 2020 from the studied localities and water wells along Feiran basin. All the characteristic and physicochemical parameters of soil (TDS, EC, PH, Na⁺, Mg²⁺, Ca²⁺, K⁺, Cl⁻, SO₄²⁻, CaCO₃⁻, HCO₃⁻, SAR, eU, eTh, eK, eRa, Ba, Pb, Nb, V, Rh, Y, Sr, Ga, Zr, Zn, Ni, Cu, Cr, soil texture, soil water content and organic matter content) as well as groundwater samples were analyzed. The physicochemical parameters of the studied soils showed that, most soil texture of Wadi Feiran soil was sand (59.65% to 91.28%), it have low contents of water and organic matter (0.9-9.9 mg/L), safe limit of radioactivity eU (1-14 ppm) and moderate limits of major ions, TDS (22.4-5564.8 mg/L), PH and EC and low to moderate limit of trace elements except zirconium, barium and chromium. Therefore Wadi Feiran studied soils considered one of the most promising soil profiles for agriculture uses especially those crops that don’t need to large quantities of water due to the habit of soil texture especially at the upper and middle sectors of stream channels.

Keywords: Soil quality, Groundwater, physicochemical, Wadi Feiran, Sinai. Egypt.

1. Introduction
Sinai Peninsula is one of the most promising regions for development in Egypt. Development of Sinai Peninsula is at the core of the national developing strategy of Egypt. The Egyptian Government pays special attention to Sinai development policies and plans such as the 1980 development plan sponsored by the Ministry of Reconstruction, and the 1994–2017 National Plans for Sinai Development. Soil quality is defined as the capacity of soil to fulfill ecological functions and provide ecosystem services to maintain biological productivity and environmental quality and enhance the plant and animal health (Bunemann et al., 2018). Resistance and quick recovery to perturbations (natural or manmade) is a characteristic of healthy soil (Schaeffer et al., 2016).

Soil quality is the competence of soil to perform necessary functions that are able to maintain animal and plant productivity of the soil. Soil consists of various physical, chemical, and biological parameters, and all these parameters are involved in the critical functioning of soil. There is a need for continuous assessment of soil quality as soil is a complex and dynamic constituent of Earth’s biosphere that is continuously changing by natural and anthropogenic disturbances. Any perturbations in the soil cause disturbances in the physical (soil texture, bulk density, etc.), chemical (pH, salinity, organic carbon, etc.). These physical and chemical parameters can serve as indicators for soil quality assessment.

The more accurate and better soil assessment can be provided by the integration of various factors such as physical, chemical and biological, these factors should be used in combination as indicators of soil quality assessment (Liao et al., 2014). Natural disturbances and agricultural practices such as tillage,
irrigation, burning, and application of pesticides and fertilizers cause an imbalance in physical and chemical parameters such as soil texture, soil moisture, pH, and organic matter (Vallejo et al., 2012). Organic matter also serves as an important indicator for determining soil fertility and soil health (Anikwe 2006; Obalum et al., 2017).

Soil constitutes a major component of the terrestrial environment and holds various living forms including microorganisms which help in nutrient recycling in the environment and serve as an excellent bioindicator tool to monitor the environmental quality and ecological changes because they respond quickly to any perturbation in the soil ecosystem (Winding et al., 2005). Soil quality assessment cannot be defined by measuring single characteristics of soil (Seybold et al., 1998), and it would be impossible to use all soil characteristics for assessing soil quality; thus, a minimum dataset (MDS) is required which consists of a core set of characteristics including physical, chemical, and biological soil properties which help to monitor soil fertility, health, and its quality (Rezaei et al., 2006; Yu et al., 2018).

Groundwater is the major source of water for domestic, agricultural and industrial purposes in Wadi Ferain area. It is estimated that approximately one third of the world’s population use groundwater for drinking. Water quality is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices. Once undesirable constituents enter the ground, it is difficult to control their dissolution. The chemical characteristics of groundwater and soil play an important role in classification and assessing water/soil quality. Geochemical studies of groundwater and soil provide a better understanding of possible changes in quality.

Study area:

The study area lies in southwestern part of Sinai, Egypt, between longitudes 28° 29' 1" & 28° 55' 6" N and latitudes 33° 10' 35" & 34° 2' 22" E, (Fig. 1). It can be reached to Wadi Ferain area through an international high way of the high asphaltic road that extends between Saint Kathrine city and Ahmed Hamdy tunnels.

Wadi Ferain is an important drainage basin in southwest Sinai Peninsula covering an area of about 1879 km, its streams drain into the Gulf of Suez crossing variety of rocks and sedimentary units varied in age from Precambrian to Quaternary.

Wadi Ferain basin is one of the most promising areas in southwestern Sinai (Egypt) for establishing new communities and for growth in agriculture, tourism, and industry. Hydrogeologically, Wadi Ferain basin classified into three main aquifers could be delineated and classified into the Quaternary aquifer, the Cretaceous-Miocene aquifer system and the Basement aquifer (Abu El Magd, 2003). The studied basin comprises the highest peaks in Egypt that receive a great part of runoff attaining 89316.2 mm (Abu El Magd, 2003). A great part of this water reaches to the Gulf of Suez and the other part percolating downwards through the pore spaces or fractures, then reach to the different aquifers. Alluvium and Lacustrine deposits form reasonable reservoirs for groundwater accumulations in the main channel of Wadi Ferain.

Climatologically, Generally, South Sinai is characterized by an arid to extremely arid climate (Lamei 2007; Omar 2014; Khafagi and Abdullah 2016). Based on data from the St. Katherine meteorological station (EMA 2013), the monthly average maximum air temperature ranged between 13.7 °C (Jan) and 32.3 °C (Aug). The monthly average minimum air temperature ranged between 2.9 °C (Jan) and 19.0 °C (Jul). The monthly average relative humidity ranged between 25% (May) and 44% (Jan). Precipitation in the study area occurred mostly in winter with a monthly average range between 0.0 mm (Jul) and 6.7 mm (Jan). Historical records indicate that extreme rainfall events occur in the study area and have increased in recent years leading to surface runoff (flash floods) that may cause damage to lives and property, and may constrain sustainable development (Gado 2017).

The present work aims to study a numbers of parameters to evaluate the soil of Wadi Ferain for agriculture purposes. To achieve this study, thirteen soil profiles and twenty-five water samples were collected during Jan., 2020 from the studied localities and water wells along Feiran basin. All the characteristic and physicochemical parameters of soil (TDS, EC, PH, Na⁺, Mg²⁺, Ca²⁺, K⁺, Cl⁻, SO₄²⁻, CaCO₃⁻, HCO₃⁻, SAR, eU, eTh, eK, eRa, Ba, Pb, Nb, V, Rb, Y, Sr, Ga, Zr, Zn, Ni, Cu, Cr, soil texture, soil water content and organic matter content) as well as groundwater samples were analyzed.
Fig. 1: Location map of the study area.

**Geologic setting:**

Wadi Feiran area geologically consists of six rock types, metamorphic rocks, younger granites, older granites, volcanic, sedimentary rocks and quaternary Wadi deposits (Figs. 2 and 3). Most of Wadi Ferain mega basin is covered with peaks of granitic and volcanic rock varieties especially along its high altitudes.

Metamorphic and sedimentary rocks occupy the middle and lower reaches of the concerned basin. Most of these rocks composed of igneous rock of which older and younger granites that’s characterized by their fractures and joints which act as natural channels for moving and catchment of groundwater. A numerous dikes which are vary between basic to intermediate in their composition. Ferain metamorphic complex of Sinai Peninsula is among the highest grade metamorphic complexes in the Arabian–Nubian Shield (Abu-Alam, 2010).

These rocks are represented as a NW- trending gneiss belt that is about 40 km long and 5–10 km wide intruded by granitic plutons and dyke swarms of porphyritic granites and dolerites. Sedimentary rocks at Wadi Ferain belong to Cretaceous-Miocene age, consist of non-marine siliciclastic (McClay et al., 1998) and a lower open marine mixed siliciclastic-carbonates and an upper carbonates- dominated sequence and evaporate with dolomitic rocks. The Quaternary deposits are distributed along the drainage lines and their composition and texture differ from one Wadi to another, reflecting the composition of the watershed areas. The terraces represent a famous structure in the basin boundaries. The studied area is covered by Precambrian igneous and metamorphic rocks consisting of gneisses and granites occupy the study area and sedimentary rocks occupy a lesser areal extent at the western part of the catchment area. Exist nonconformity between Precambrian rocks and overlain non-metamorphosed sediments cropping out to the north and west of the area. Well-stratified lacustrine sandy and pebbly deposits fill the main Wadis as Feiran and El Sheikh. Remnants of such lacustrine beds are still hanging on the slopes of some hills in Feiran Oasis.
Mineralologically, these dykes are acidic albite or rhyolite, red porphyry or trachyite types and basic or basaltic dykes. From the structural the floor of the main Wadi and plains are covered by Quaternary alluvial deposits (Kassem, 1981). Both igneous and metamorphic rocks in the area under investigation are invaded by dykes of different compositions and variable point of view, faults, folds, foliation and joints affect the study area, (Fig. 3).

Fig. 3: Field photograph shows the gneisses rocks, quaternary rocks (A), sedimentary rocks (B), granites rocks (C), gneisses rocks (D), granite dikes (D) and alkali-feldspar granites (F).

2. Materials and Methods

To access the quality of soil and groundwater, 13 soil section (39 soil samples) and 25 groundwater samples were collected along Wadi Ferain (Fig.4) with global positioning system (GPS) during June 2020.
Fresh groundwater samples were collected in sterilized polythene bottles of 500 ml. All water samples were filtered through 0.45 μm, (pH, EC and temperature) of the water samples was measured on spot by using pH meter (Eco Scan Ion-6, Singapore), Electric conductivity (EC) were measured by portable EC meter and Temperature was also measured simultaneously by using the same meter. Soil samples were collected through 13 sections divided to A, B and C with space between ranged from 30cm to 150cm and putting in sampling bags. The location of all wells and soil were determined by (GPS), the depth of wells and depth to water was measured also with help the well owner’s. The titration methods (Shapiro and Branock, 1962) were used for determination of chloride (Cl), calcium (Ca), (SAR) sodium adsorption ratio and magnesium (Mg). Spectrophotometric analysis is used for determination the sulfate (SO₄) as well as Flame photometer analysis for determining sodium (Na) and potassium (K). Additionally, the trace elements concentration; uranium (U), cadmium (Cd), lead (Pb), iron (Fe), cobalt, (As) and zinc (Zn) were analyzed using Inductively Coupled Plasma Optical Emission Spectrometry (720 ICP-OES Agilent Technologies, Santa Clara, CA, USA). Also, the organic matter content of soil samples was determined by loss on ignition method after oven drying at 600 C for 3 h. Typically particle size analyses, as (less than 2mm) soil sample were dried in air, and then passed through a 2mm sieve to evaluate gravel percent. Particle size was determined by pipette method for sand, silt and clay. Trace elements (Cr, Cu, I, Zn, Zr, Ga, Sr, Y, Rb, V, Nb, Pb and Ba) were determined by (X-Ray Fluorescence Unit). Radiometrically, the soil samples were analyzed to their equivalent radiation (eU, eTh, eK and eRa) by high germanium technique.

All these analyses were carried out at the central laboratory of the Nuclear material authority (NMA) and Soil Water and Environment Institute, Agricultural Research Centre (ARC).

![Fig. 4: Field photographs shows, Sampling (A and B), cultivation (C, D and E) and Feiran Oasis (F).](image-url)

### 3. Results and Discussion

Thirteen representative soil sections have been obtained from will defined stations scattered along Wadi Feiran. These samples have been collected during Janu 2020, were analyzed for their major ions, physiochemical parameters, their organic matter (OM), Sodium adsorption ratio (SAR), mechanical analyses, equivalent radiometric measurement and trace elements content (Table 1).

#### 3.1. Soil characteristics:

 Soil texture plays an important role in determination of bulk density and quality of soil (Martin et al., 2017). The mechanical analyses of Wadi Feiran soil illustrate their textures; sand considers the main component and ranged from 59.65% to 91.28% with an average of 82.53%. Silt ranges from 7.23% to 21.75% with an average of 11.28%. Clay is ranges from 1.24% to 20.24% with an average of 6.19%, so the texture of Wadi Feiran basin ranged from sand, loamy sand, sandy clay loam and loamy sand (Table 1). A measure of corresponding percentage of sand, silt, and clay inside a layer of soil is
termed as soil texture (Tabor et al., 2017). Thus Wadi Feiran soil consider low soil water content due their texture, reduction in water availability in the soil causes reduction in growth and activity of soil microbes which affects the mineralization of nutrients in the soil (Geisen et al., 2014; Yan et al., 2015).

3.1.2. Chemical characteristics of soil:

Soil salinity (EC) is defined as the agglomeration of soluble mineral salts present in the soil (Tanji 2002). Excess amounts of salts present in soil can affect the productivity of soil (Yan et al., 2015). Deposition of dissolvable salts in the soil could be responsible for soil salinization (De Souza Silva and Fay 2012). Presence of excess amounts of salt increases the osmotic potential of the soil water which causes drawing out water from the cell which may kill the microorganisms present in soil (Yan et al., 2015). Thus, salinity causes a decline in soil fertility. It has also been reported that increment in salinity also destroys soil structure (De Souza Silva and Fay 2012). (EC) in the study soil ranged from 505.6 µs/cm to 88025.6 µs/cm with an average of 13685.5 µs/cm (Fig. 5A), where TDS in the studied soil ranged from 22.44 ppm to 5564.83 ppm with an average of 741.56 ppm (Fig. 5B).

pH is defined as the concentration of hydrogen ions in soil solution (Mc Lean 1983). pH is considered to be a significant soil property as it determines the nutrient accessibility and the physical condition of the soil controlling the diversity of microbes in soil. PH influences the buffering capacity and quality of organic substances in soil (Usharani et al., 2019). PH in studied soil ranged from 3.95 to 11.84 with an average of 7.75 (Table 1).

| No. | Parameter | Unit | Maximum | Minimum | Average |
|-----|-----------|------|---------|---------|---------|
| 1   | TDS       | mg/L | 5564.83 | 22.44   | 741.56  |
| 2   | EC        | µs/cm| 88025.6 | 505.6   | 13685.5 |
| 3   | PH        | -----| 11.84   | 3.95    | 7.75    |
| 5   | Na+       | mg/L | 973.91  | 0.8     | 113.83  |
| 6   | K+        | mg/L | 64.18   | 0.2     | 7.35    |
| 7   | Ca++      | mg/L | 1018.42 | 2.6     | 138     |
| 8   | Mg++      | mg/L | 363.44  | 0.42    | 41.06   |
| 9   | Cl-       | mg/L | 1400    | 4.2     | 172.99  |
| 10  | SO4--     | mg/L | 1141.3  | 1.92    | 126.72  |
| 11  | CaCO3-    | mg/L | 4.76    | 0.41    | 1.66    |
| 12  | HCO3-     | mg/L | 4.25    | 0.94    | 1.93    |
| 13  | SAR       | -----| 4.04    | 0.03    | 0.79    |
| 14  | O.M       | mg/L | 9.9     | 0.1     | 3.16    |
| 15  | eU238     | Ppm  | 14      | 1       | 2.81    |
| 16  | eTh232    | Ppm  | 29      | 2       | 9.92    |
| 17  | eRa226    | Ppt  | 2.4     | 0.5     | 1.02    |
| 18  | eK        | %    | 3.02    | 0.78    | 1.82    |
| 19  | Ba        | Ppm  | 502     | 88      | 294.67  |
| 20  | Pb        | Ppm  | 7       | 2       | 3.72    |
| 21  | Nb        | Ppm  | 31      | 5       | 12.41   |
| 22  | V         | Ppm  | 104     | 12      | 65.54   |
| 23  | Rb        | Ppm  | 8       | 2       | 4.97    |
| 24  | Y         | Ppm  | 10      | 2       | 4.49    |
| 25  | Sr        | Ppm  | 289     | 47      | 113.18  |
| 26  | Ga        | Ppm  | 28      | 2       | 11.06   |
| 27  | Zr        | Ppm  | 939     | 145     | 382.36  |
| 28  | Zn        | Ppm  | 55      | 24      | 34.72   |
| 29  | Ni        | Ppm  | 84      | 35      | 55.38   |
| 30  | Cu        | Ppm  | 32      | 14      | 20.77   |
| 31  | Cr        | Ppm  | 165     | 53      | 124.15  |

Soil organic matter (SOM) is a mixture containing both decomposed and nondecomposed microorganisms and plant debris (Arias et al., 2005). SOM is considered to be an important indicator for monitoring soil degradation and soil erosion as it affects the aggregation of soil and its stability. (Oldfield et al., 2018) have reported that high concentration of SOM causes an increase in water holding capacity of the soil. It has been reported that SOM acts as a buffering agent that limits sudden chemical
and temperature changes occurring in the soil (Mohammadi et al., 2011). SOM in the studied soil characterized by low content due to their texture and it is ranged from 0.1 mg/L to 9.9 mg/L with an average of 3.16 mg/L (Fig. 5K).

Fig. 5: Physicochemical parameters of the studied soil, Ec (A), TDS (B), Na (C), Ca(D), Mg (E), K (F), Cl (G), SO4 (H), CaCO3 (I), HCO3 (J), O.M (K), SAR (L).
Cation exchange capacity is the ability of soil to absorb cations from the soil and impart a negative charge to the soil (Graber et al., 2017). It also provides buffering capacity against pH change in the soil (Moral and Rebollo 2017; Rahal and Alhumairi 2019). Cation exchange capacity (CEC) acts as a sensitive indicator for determining nutrient holding capacity of the soil, its fertility and long term productivity (Graber et al., 2017; Moral and Rebollo 2017). Soils with high CEC also have high clay content and high water holding capacity (Moral and Rebollo 2017; Rahal and Alhumairi 2019). Also, soil with high CEC requires less application of fertilizers (Shiri et al., 2017).

CEC increases with the increase in pH (Graber et al., 2017). Soils with higher CEC have high organic matter and soils with high organic matter also have higher microbial diversity and abundance (Xu et al., 2016). From the above information, Wadi Feiran soil classified as low CEC.

Major ions distributions in the soil are illustrated in (Tab. 1 and Figs. 5A, B, C, D, E, F, G, H, I and J). The concentrations of (Na⁺) in the studied soil varied from 0.8 mg/L to 973.91 mg/L with an average of 113.83 mg/L (Fig. 5C). (Na⁺) is positively correlated with TDS. The low concentration of (Na⁺) in upstream is as a result of low weathering rate of basement rocks. The concentration of (Ca²⁺) varied from 2.6 mg/L to 1018.42 mg/L with an average of 138 mg/L (Fig. 5D). Magnesium (Mg²⁺) concentrations varied from 0.42 mg/L to 363.44 mg/L with an average of 41 mg/L (Fig. 5E) The concentrations of (K⁺) in the studied soil range from 0.2 mg/L to 64.18 mg/L with an average of 7.35 mg/L (Tab.1 and Fig. 5F). Potassium (K⁺) is the third significant essential macronutrient after nitrogen and phosphorus for plant productivity (Jaiswal et al., 2016; Sattar et al., 2019). It is abundantly available inside the Earth’s crust (Rao and Srinivas 2017). Inadequate potassium in the soil causes reduction in product yield of crops and quality of crops reduces root development in plants (Jaiswal et al., 2016). The lower concentration of K⁺ in soil is due to the lack of human activities and fresh water intrusion in soil through rains.

The high concentration of (Ca²⁺) and (Mg²⁺) in soil located at the downstream of Feiran are most probably derived from leaching of carbonate minerals such as calcite and dolomite (Magesh et al., 2013) that exist in Cretaceous- Miocene sediments in downstream of southwest Wadi. In addition to weathering process of igneous and metamorphic rocks which have (Ca²⁺) in its plagioclase feldspars.

Chloride (Cl⁻) concentration varies between 4.2 mg/L to 1400 mg/L with an average of 172.99 mg/L (Fig. 5G). The high concentrations of (Cl⁻) in the soil may be attributed to contamination due to the human activities in this region, the increment in (Cl⁻) content along downstream may due to the Cretaceous- Miocene aquifer that characterized by its high content of evaporates rocks.

Sulfate (SO₄²⁻) concentrations in the studied soil range from 1.92 mg/L to 1141.3 mg/L with an average of 126.72 mg/L (Tab.1 and Fig. 5H). The possible source of (SO₄²⁻) in soil may be derived from leaching of sulfate components of gypsum-bearing rocks of Cretaceous- Miocene age.

Calcium carbonate (CaCO₃) values ranged from 0.41 mg/L to 4.76 mg/L with an average of 1.66 mg/L (Tab.1 and Fig. 5I).

Bicarbonate (HCO₃⁻) concentration ranged from 0.94 mg/L to 4.25 mg/L with an average of 1.93 mg/L (Fig. 5J). The low concentration of (HCO₃⁻) in Feiran soil sampled may be due to the low weathering intensity of basement rocks in upstream of the Wadi.

The sodium adsorption ratio (SAR) is a parameter measuring the soil hazard because of its direct relation to the adsorption of sodium by soil. SAR ratio in the studied soil ranged from 4.04 mg/L to 0.03 to 4.04 with an average of 1.93 (Fig. 5L). The concentration of Na⁺ can decrease the permeability and structure of soil (Todd, 2009). The low SAR ratio considers a suitable for agriculture uses under the prevailing conditions. Soil of Wadi Feiran basin is considering a good Soil for agriculture because they have moderate TDS, EC, major ions and low (SAR) ratio especially in the middle part and upstream of the Wadi.

Radiometrically, after analyses of 39 soil sample to their equivalent radiation (eU, eTh, eK and eRa) (Tab.1 and Fig. 6M, N, O and P) and due to parent rocks background, Equivalent uranium (eU) value in the studied soil samples ranged from 1 ppm to 14 ppm with an average of 2.81 ppm (Fig. 6M). Equivalent thorium (eTh) value in the studied soil is ranged from 2 ppm to 29 ppm with an average of 9.92 ppm (Fig. 6N). Equivalent potassium (eK) is ranged from 0.78 % to 3.02 % with an average of 1.82 % (Fig. 6O). Equivalent radon (eRa) values ranged from 0.5 ppt to 204 ppt with an average of 1.02 ppt (Fig. 6P).
Trace elements distribution (Cr, Cu, I, Zn, Zr, Ga, Sr, Y, Rh, V, Nb, Pb and Ba) in the studied soil are shown in (Tab. 1 and Figs. 7A, B, C, D, E, F, G, H, I, J, K, L and M). Barium (Ba) concentration in the soil was ranged from 88 ppm to 502 ppm with an average of 294.67 ppm (Fig. 7A).

Lead (Pb) concentration was varied from 2 ppm to 7 ppm with an average of 3.72 ppm (Fig. 7B). Vanadium (V) concentration in the soil ranged from 12 ppm to 104 ppm with an average of 65.54 ppm (Fig. 7C). Rubidium (Rb) value ranged from 2 ppm to 8 ppm with an average of 4.97 ppm (Fig. 7D). Yttrium (Y) concentration ranged from 2 ppm to 10 ppm with an average of 4.49 ppm (Fig. 7E). Strontium (Sr) values in the studied soil were ranged from 47 ppm to 289 ppm with an average of 113.18 ppm (Fig. 7F).

Gallium (Ga) concentration was ranged from 2 ppm to 28 ppm with an average of 11.06 ppm (Fig. 7G). Zircon concentration in the soil ranged from 145 ppm to 939 ppm with an average of 382.36 ppm (Fig. 7H). Zinc concentration in the studied soil ranged from 24 ppm to 55 ppm with an average of 34.72 ppm (Fig. 7I). Nickel concentration in Feiran soil ranged from 35 ppm to 84 ppm with an average of 55.38 ppm (Fig. 7J). Mercury (Cu) in the soil ranged from 14 ppm to 32 ppm with an average of 20.77 ppm (Fig. 7K).

Chromium (Cr) concentration in Feiran soil ranged from 53 ppm to 165 ppm with an average of 124.15 ppm (Fig. 7L). Trace element concentrations in the studied soil are generally moderate to low. This may have attributed to the intimate contact with mineralized rock or ore bodies (Davis and Dewiest, 1966). The origin of these trace elements is suggested to be divided between the weathering of rocks, or may be introduced into the atmosphere and hydrosphere by human activities.

Twenty-five representative groundwater samples were collected along Wadi Feiran to evaluate the groundwater for irrigation purpose. All the physicochemical parameters were studied and mainly computable with (FAO, 2010c) standard for irrigation water (Table 2). The concentration of major cations Na⁺, K⁺, Ca²⁺ and Mg²⁺ are ranged from 36.01 mg/L to 171.3 mg/L, 1.5 mg/L to 4.93 mg/L, 78.21 mg/L to 439.4 mg/L and 11.24 mg/L to 100.7 mg/L with an average of 94.9 mg/L, 2.42 mg/L, 173.7 mg/L and 44.34 mg/L respectively. The concentration of major anions Cl⁻, SO₄²⁻, and HCO₃⁻ in the studied groundwater are ranged from 60.17 mg/L to 451.27 mg/L, 172.5 mg/L to 1102 mg/L and 59.78 mg/L to 139.86 mg/L with an average of 170.96 mg/L, 476.95 mg/L and 88.95 mg/L respectively (Figs. 8A, B, C, D, E, F, G, H and I).

Trace element concentrations in the studied groundwater are generally moderate to low. This may have attributed to the intimate contact with mineralized rock or ore bodies (Davis and Dewiest, 1966). The origin of these trace elements is suggested to be divided between the weathering of rocks, or may be introduced into the atmosphere and hydrosphere by human activities.

Fig. 6: Radiometric parameters of the studied soil, eU (M), eTh (N), eK (O), eRa (P).
Fig. 7: Trace elements distribution in the studied soil, Ba (A), Pb (B), Nb (C), V (D), Rb (E), Y (F), Sr (G), Ga (H), Zr (I) and Zn (J).
Table 2: Physicochemical parameters distributions in the study groundwater points (mg/l).

| No. | Parameter | Unit   | Maximum  | Minimum  | Average | FAO 2010 |
|-----|-----------|--------|----------|----------|---------|----------|
| 1   | TDS       | mg/L   | 2286.53  | 424.99   | 1048.88 | 2500     |
| 2   | EC        | µs/cm  | 2201.6   | 441.6    | 1048.94 | 3000     |
| 3   | PH        | ----   | 7.8      | 7.1      | 7.42    | 6-8.5    |
| 4   | Na⁺       | mg/L   | 171.3    | 36.01    | 94.9    | 920      |
| 5   | K⁺        | mg/L   | 4.93     | 1.5      | 2.42    | 1        |
| 6   | Ca²⁺      | mg/L   | 439.4    | 78.21    | 173.7   | 400      |
| 7   | Mg²⁺      | mg/L   | 100.7    | 11.24    | 44.34   | 60       |
| 8   | Cl⁻       | mg/L   | 451.27   | 60.17    | 170.96  | 1065     |
| 9   | SO₄²⁻     | mg/L   | 1102     | 172.5    | 476.95  | 961      |
| 10  | HCO₃⁻     | mg/L   | 139.86   | 59.78    | 88.95   | 610      |
| 11  | SAR       | ----   | 3.21     | 0.91     | 1.76    | 15       |
| 12  | U         | Ppb    | 38       | 19       | 27.24   | 50       |
| 13  | Th        | Ppb    | 66       | 34       | 47.6    | 100      |
| 14  | Fe        | Ppb    | 140      | 29       | 97.08   | 5000     |
| 15  | As        | Ppb    | 101      | 12       | 41.12   | 100      |
| 16  | Zn        | Ppb    | 251.1    | 18       | 124.64  | 2000     |
| 17  | Mn        | Ppb    | 251      | 12       | 85.49   | 200      |
| 18  | Cr        | Ppb    | 32       | 1        | 16.2    | 100      |
| 19  | Co        | Ppb    | 26.72    | 3.92     | 13.39   | 50       |
| 20  | Pb        | Ppb    | 124      | 18       | 71.64   | 5000     |
Fig. 8: Physicochemical parameters of the studied groundwater, Ec (A), TDS (B), Na (C), Ca(D), Mg (E), K (F), Cl (G), SO4 (H), HCO3 (I).
These trace constituents include Pb\(^{2+}\), Zn\(^{2+}\), As\(^{3+}\), Th, Co, Cr, Mn, Fe\(^{2+}\) and U\(^{238}\) (Table 2 and Figs. 9A, B, C, D, E, F, G, H and I). These elements are discussed and classified into the following two groups: toxic elements (As\(^{3+}\), Pb\(^{2+}\), Th\(^{232}\) and U\(^{238}\)), metallic elements (Cr\(^{3+}\), Fe\(^{2+}\) and Zn\(^{2+}\)) and transition
elements (Co$^{2+}$ and Mn$^{2+}$). Toxic elements concentration ranged from 12 ppb to 101 ppb, 18 ppb to 124 ppb, 34 ppb to 66 ppb and 19 ppb to 38 ppb with an average of 41.12 ppb, 71.74 ppb, 47.6 ppb and 27.24 ppb respectively. Transition elements concentration was ranged from 3.92 ppb to 26.72 ppb and 12 ppb to 251 ppb with an average of 13.39 ppb and 85.76 ppb. Metallic elements concentration ranged from 1 ppb to 32 ppb, 29 ppb to 140 ppb and 18 ppb to 251 ppb with an average of 16.2 ppb, 97.08 ppb and 124.64 ppb respectively.

**Conclusion and recommendation**

From the above results Wadi Feiran basin has a moderate to good parameters for soil quality especially TDS, EC, PH and all major ions according to FAO. Soil texture of Feiran mainly Sand that reflect their low organic matter and soil water content. Main ions especially that’s have low ionic potential Na, Ca, Mg and K consider mobile elements and their ions exchange normally low (cations exchange). Equivalent parameters generally weak to moderate especially uranium which reflected the importance of this soil. Trace elements concentration low to moderate except zirconium, barium, strontium and chromium have moderate to high values. Groundwater of Wadi Feiran consider for irrigation purpose due to their physicochemical parameters and to (WHO, 2018) constant for irrigation water.

On the basis of the present study, the following recommendations have been proposed:
1- Interest in sessional agriculture in Wadi Feiran basin.
2- Attention to crops that don’t need to large quantities of water due to the soil texture.
3- Paying attention to establishing dams and water barriers to make use of water in agriculture.

**References**

Abraham, J.S., S. Sripoorna, J. Dugar, S. Jangra, A. Kumar, K. Yadav, S. Singh, A. Goyal, S. Maurya, G. Gambhir, R. Toteja, R. Gupta, D.K. Singh, H. El-Serehy, N.J. Taboor, T.S. Myers, and L.A. Michel, 2019. Sedimentologist’s guide for recognition, description and classification of paleosols. In K. E. Zeigler and W. G. Parker (Eds.), Terrestrial depositional systems: deciphering complexities through multiple stratigraphic methods (165–208). Amsterdam: Elsevier.

Anikwe, M.A.N., 2006. Soil quality assessment and monitoring: a review of current research efforts. Emgu: New Generation Books.

Arias, M.E., J.A. Gonzalez-Perez, F.J. Gonzalez-Vila, and A.S. Ball, 2005. Soil health: a new challenge for microbiologists and chemists. International Microbiology, http://hdl.handle.net/10261/2130

Abu-Alam, T.S., 2010. Metamorphic and Structural Evolution of the Wadi Feiran Complex, Southwest Sinai; Doctor of Science, Doctoral School of Earth Sciences, Karl-Franzens University of Graz, 133p.

Abu El-Magd, A.A., 2003. Quantitative hydrogeological studies on Wadi Feiran Basin, South Sinai, with emphasis on the prevailing environmental conditions. MSc thesis Geol. Dept., Fac. Sci., Suez Canal University. Egypt, 252.

Bunemann, E.K., G. Bongiorno, Z. Baic, R.E. Creamerb, G.D. Deynb, R.D. Goedeb, L. Fleskensd, V. Geissend, T.W. Kuyperb, P. Madera, M. Pullemanb, W. Sukkelf, J.W.V. Groenigenb, and L. Brussaard, 2018. Soil quality acritical review; Soil Biology and Biochemistry. https://doi.org/10.1016/j.soilbio.2018.01.030.

Davis, S.N., and R.J. De Wiest, 1966. Hydrogeology Wiley, New York, 463 .

De Souza Silva, C.M.M., and E.F. Fay, 2012. Effect of salinity on soil microorganisms. In M. C. Hernandez-Soriano (Ed.), Soil Health and Land Use Management (177–198). Croatia: Intech.

EMA, Egyptian Meteorological Authority, 2013. The monthly meteorological normal for Saint Katherine, database. EMA, Cairo.

FAO, 2010c. Global Forest Resources Assessment 2010-key findings. Rome. Foris.fao. org/static /data/fr/a2010/keyfindings-en.pdf.

Gaber, A., E. Ghoneim, F. Khalaf, and F. El-Baz, 2009. Delineation of paleolakes in the Sinai Peninsula, Egypt, using remote sensing and GIS; J. Arid Environ. 73: 127–134. Doi:10.1016/j.jaridenv.2008.08.007.

Gado, T.A., 2017. Statistical characteristics of extreme rainfall events in Egypt. IWTC20, Hurghada, Egypt, 18–20 May 2017, 645.
Grabr, B.R., B. Singh, K. Hanley, and J. Lehmann, 2017. Determination of cation exchange capacity in biochar. In B. Singh, M. Camps-Arbestain, and J. Lehmann (Eds.), Biochar: A Guide to Analytical Methods (74–84). Boca Raton: CRC Press LLC.

Jaiswal, D.K., J.P. Verma, S. Prakash, V.S. Meena, and R.S. Meena, 2016. Potassium as an important plant nutrient in sustainable agriculture: a state of the art. In V. S. Meena, B. R. Maurya, J. P. Verma, and R. S. Meena (Eds.), Potassium solubilizing microorganisms for sustainable agriculture (21–29). India: Springer.

Jowile, R., D.C. Suyal, and B.D. Narayan, and R. Soni, 2017. Soil metagenomics: a tool for sustainable agriculture. In V. C. Kalia, Y. Shouche, H. J. Purohit, and P. Rahi (Eds.), Mining of microbial wealth and metagenomics (217–225). Singapore: Springer.

Kassem, M., 1981. Hydrogeological studies in Wadi Feiran, South Western Sinai. MSc Thesis, Suez Canal University, Egypt, 181.

Khtafagi, O.A., and A. Abdullah, 2016. Assessment of environmental influences on the vegetation of Taba protected area, South Sinai, Egypt. IOSR J Environ Sci Toxicol Food Technol 10(11 Ver. II):45–54. https://doi.org/10.9790/2402-1011024554

Lamei, A., 2007. Need and potential for aquifer storage recovery in Egypt. 11th Int. Water Technology Conference, IWTC11 2007 Sharm El-Sheikh, Egypt, 663–667.

Liao, Y., X. Min, Z. Yang, L. Chai, S. Zhang, and Y. Wang, 2014. Physicochemical and biological quality of soil in hexavalent chromium-contaminated soils as affected by chemical and microbial remediation. Environmental Science and Pollution Research https://doi.org/10.1007/s11356-013-1919-z.

Magesh, N., S. Krishnakumar, N. Chandrasekar, J.P. Soundranayagam, 2013. Groundwater quality assessment using WQI and GIS techniques, Dindigul district, Tamil Nadu, India. Arab J. Geosci 6:4179–4189. Doi:10.1007/s12517-012-0673-8.

McLean, E.O., 1983. Soil pH and lime requirement. In A. L. Page (Ed.), Methods of Soil Analysis (199–224). Madison: American Society of Agronomy, Inc.

McClay, K.R., G.J. Nichols, S.M. Khalil, M. Darwish, and W. Bosworth, 1998. Extensional tectonics and sedimentation, eastern Gulf of Suez, Egypt; In: Sedimentation and tectonics in rift basins Red Sea: Gulf of Aden, Springer, 223–238. Doi:10.1007/978-94-011-4930-3_14.

Mohammadi, K., G. Heidari, S. Khalesro, and Y. Sohrabi, 2011. Soil management, microorganisms and organic matter interactions: a review. African Journal of Biotechnology. https://doi.org/10.5897/AJB11.006.

Moral, F.J., and F.J. Rebollo, 2017. Characterization of soil fertility using the Rasan model. Journal of Soil Science and Plant Nutrition. https://doi.org/10.4067/S0718951620170000035.

Obalum, S.E., G.U. Chibuoke, S. Peth, and Y. Ouyang, 2017. Soil organic matter as sole indicator of soil degradation. Environmental Monitoring and Assessment https://doi.org/10.1007/s10661-017-5881-y.

Oldfield, E.E., S.A. Wood, and M.A. Bradford, 2018. Direct effects of soil organic matter on productivity: a mirror of other organic amendments. Plant and Soil. https://doi.org/10.1007/s11104-017-3513-5.

Ornar, K.A., 2014. Evaluating the effectiveness of in-situ conservation on some endemic plant species in South Sinai, Egypt. Am. J. Life Sci., 2(3):164–175. https://doi.org/10.11648/j.ajls.20140203.16.

Rahal, N.S., and B.A.J. Alhumairi, 2019. Modelling of soil cation exchange capacity for some soils of east gharaf lands from mid-Mesopotamian plain (Wasit province/Iraq). International journal of Environmental Science and Technology. https://doi.org/10.1007/s13762-018-1913-6.

Rao, C.S., and K. Srinivas, 2017. Potassium dynamics and role of non-exchangeable potassium in crop nutrition. Indian Journal of Fertilizer’s, 13(4): 80–94.

Rezace, S.A., R.J. Gilkes, and S.S. Andrews, 2006. A minimum data set for assessing soil quality in rangelands. Geoderma. https://doi.org/10.1016/j.geoderma.2006.03.021.

Sattar, A., M. Naveed, M. Ali, Z.A. Zahir, S.M. Nadeem, M. Yaseen, V.S. Meena, M. Farooq, R. Singh, M. Rahman, and H.N. Meena, 2019. Perspectives of potassium sol-ubilizing microbes in sustainable food production system: a review. Applied soil Ecology. https://doi.org/10.1016/j.apsoil.2018.09.012.

Seybold, C.A., M.J. Mausbach, D.L. Karlen, and H.H. Rogers, 1998. Quantification of soil. In R. Lal, J. M. Kimble, R. F. Follett, and B. A. Stewart (Eds.), Soil processes and the carbon cycle (387–404). New York: CRC Press LLC.

Schaeffer, A., W. Amelung, H. Hollert, M. Kaestner, E. Kandel, J. Kruse, A. Mittler, R. Ottermanns, H. Page, S. Peth, C. Poll, G. Rambold, M. Schloter, S. Schulz, J. Shiri, A. Keshavarzi, O. Kisi, U. Iturraran-Viveros,
A. Bagherzadeh, R. Mousavi, and S. Karimi, 2017. Modeling soil cation exchange capacity using soil parameters: Assessing the heuristic models. Computers and Electronics in Agriculture. https://doi.org/10.1016/j.compag.2017.02.016.

Shabiro, L. and W.W. Branockis, 1962. Rapid analysis of silicate, carbonate and phosphate rocks: U.S. Geological survey, Bulletin 114A, 56.

Tanjii, K.K., 2002. Salinity in the soil environment. In A. Lauchli and U. Luttge (Eds.), Salinity: environment–plants–molecules (21–51). Netherlands: Springer.

Usharani, K.V., K.M. Roopashree, and D. Naik, 2019. Role of soil physical, chemical and biological properties for soil health improvement and sustainable agriculture. Journal of Pharmacognosy and Phytochemistry, 8(5): 1256–1267.

Vallejo, V.E., Z. Arbeli, W. Terán, N. Lorenz, R.P. Dick, and F. Roldan, 2012. Effect of land management and Prosopis juliflora (Sw.) DC trees on soil microbial community and enzymatic activities in intensive silvopastoral systems of Colombia. Agriculture, Ecosystems and Environment. https://doi.org/10.1016/j.agee.2012.01.022

Winding, A., K. Hund Rinke, and M. Rutgers, 2005. The use of microorganisms in ecological soil classification and assessment concepts. Ecotoxicology and Environmental Safety. https://doi.org/10.1016/j.ecoenv.2005.03.026.

Xu, N., G. Tan, H. Wang, and X. Gai, 2016. Effect of biochar additions to soil on nitrogen leaching, microbial biomass and bacterial community structure. European Journal of Soil Biology. https://doi.org/10.1016/j.ejsobi.2016.02.004.

Yan, N., P. Marschner, W. Cao, C. Zuo, and W. Qin, 2015. Influence of salinity and water content on soil microorganisms. International Soil and Water Conservation Research. https://doi.org/10.1016/j.iswcr.2015.11.003.

Yu, P., S. Liu, L. Zhang, Q. Li, and D. Zhou, 2018. Selecting the minimum data set and quantitative soil quality indexing of alkaline soils under different land uses in northeastern China. Science of The Total Environment. https://doi.org/10.1016/j.scitotenv.2017.10.301.