Journal of Agriculture and Rural Development Studies
Volume 1 – Issue 2
ISSN – Online 3061-2756
www.imadr.jards.ugal.ro

DOI https://doi.org/10.35219/jards.2024.2.02

Application of Some Physicochemical Properties of Selected Soil Samples from Mesopotamian Agricultural Plain, Iraq, Indicating Soil Erosion and Degradation

Raghad S. Mouhamad*, Khaldoun Ahmad**

ARTICLE INFO

Article history:
Accepted October 2024
Available online October 2024

Keywords:
physicochemical analysis, soil properties, soil erosion, soil texture, Mesopotamian agricultural plain

ABSTRACT

Twenty-four soil samples of 0-15 cm depth were collected from Mesopotamian agricultural plain, located in Kut-Iraq. Multiple methods determined in this study including partial size distribution size analysis, elemental analysis pH, soil electrical conductivity, Sodium Adsorption Ratio (SAR), organic matter, and Urease. High amount of salt causes the soil samples to be basic soil, pH ranges from 7 to 8, and not able to obtain adequate nutrients. All of soil samples have a dispersive property that means the soil are vulnerable to erosion by rainfall or run off. The high value of Soil electrical conductivity (EC) indicates the lack of microorganisms in soil to enhance soil health and indicate the soil damage in the study area. High Ca content in soil samples reduced K/Ca ratios which in terns impact the presence of K on soil samples. Statistical analysis between soil textures and physico-chemical properties indicate low value of erodibility (k) factor due to high concentrations of Ca. Over all, the soil in the Mesopotamian agricultural plain shows damage in the structure due to human activity and lack of vegetation covers.

1. Introduction

Mesopotamian agricultural plain, located in Iraq, is sustained by Tigris River (Morozova, 2005). The salinity accumulation of the Tigris' waters is thus a major intimidation of Iraq's economy (Rahi et al., 2010). An outdated tool is further hampering the mechanization of the Iraqi agricultural district (FAO. 2016). April to October is a dry season in the middle of Iraq representing by temperatures rises more than 53oC (AL-Salihi and Hassan, 2015) and rainfall is less than 250 mm/year (Ewaid et al., 2019). This situation is caused by climate change and drainage water rises which eventually effects on bio-environmental issues. Moreover, it impacts on future agricultural such as hindering the development of income and livelihood of the farmers and soil erosion in Iraq (Mekonnen, 2018). Shallow water table from 150-200 cm (Wu et al., 2014; ICBA, 2003), saline groundwater reached 8-12 dS m-1 (Qureshi et al., 2013), and soil salinity > 30 dS m-1 (Al-Falahii and Qureshi, 2012) are expected to aggravate by climate changes. The salinity of Tigris and Euphrates rivers in Iraq increases that impact negatively on agriculture for off-farm income employment (Qureshi, 2014). The Mesopotamian land management structure in past years has a significant cause of soil erosion. This has given the benefit of the conventional agricultural systems.

* Scientific Research Commission, Ministry of Higher Education and Scientific Research of Iraq, ** Saint Cloud Technical and Community College, Saint Cloud, Minneapolis, USA. E-mail addresses: raghad1974@yahoo.com (R. Mouhamad - Corresponding author), ahmadki@umkc.edu (K. Ahmad).

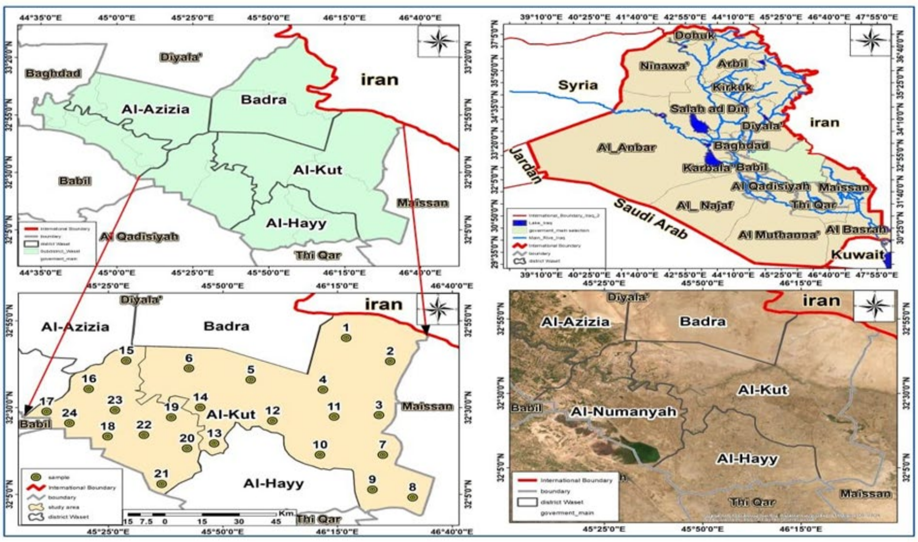
However, these have impacts on urban/rural displacement. In addition to mining practices, household organic pollutant sources and farmland use for military purposes have impact (Nidal and Amel, 2016).

Main cause soil erosion and salinity in agro-hydrological is farm inputs and soil pollution that diffuse from many ranges of sources (Yaron et al., 2012). The sources include anthropogenic, agricultural, industrial, inadequate solid, liquid waste disposal, excessive organic, mineral fertilizer, pesticide, mining, military, and accidents introduce excessive amounts of pollutants to a soil pool (Yashim et al., 2014). Therefore, the soil in the area may represent a risk to those who live or eat crops grown on the area. Nutrients are potential for plants to grow. The nutrients may be constituted as a direct source of environmental heavy metals pollution that transferred during the multi-steps production process (Vargas et al., 2016). These toxic and harmful elements may have transferred into soil or water, and eventually accumulate in plants, animals, and humans with no chance of metabolism process (Tóth et al., 2016), with considering biomagnification. The existed toxic elements with their accumulation character are considered as an exporter of serious health problems (Tangahu et al., 2011). Soil is a dynamic system and changes in the environmental conditions can alter trace and major elements and hereby affecting soil behaviour (Pierzynski et al., 2005). Factors such as pH, redox potential, temperature and bacterial activity influence the solubility, mobilization and precipitation/deposition of the trace elements (Orita, 2012). The chemical industries and fertilizers application are the most important sources of heavy metals in soils (Blum, 2005; Rauof et al., 2014; 2015), the agricultural practices (Ahmed & El-Arabi, 2005).

A research aim is to determine the soil erosion in Mesopotamian plain using physico-chemical characteristics and understand the impact of human activates and climate change on soil health in Iraq.

2. Study area

The area of study is located, between latitude (32° 30'-32°10') N and longitude (45° 50'-46° 27') E, in the central part of Iraq which is part of the Mesopotamian plain (Map 1).



Map 1. Arc Map by program10.5 (map scale 1:1000000 Iraq) 24 random samples were used to cover the study field to achieve the desired objective

Source: Mouhamad R., 2024

Geologically, the area represents Quaternary deposit that is divided into Pleistocene deposits and Holocene deposits (FAO, 2003). Study area soil contains substantial amounts of chemical and organic substances vertical and horizontal differences in the composition of the soil are distinguished and silt clay texture in the sample soil has been predominant. PH concentrations in alkaline were moderate to acidic. The difference in the mineral values of calcium carbonate, the quality of organic matter with a reduction of soluble cations and anions and increased in gradient strength and short distance at the banks of the River Tigris. The difference was completely free and amorphous in the amount of iron oxides. There was a totally free and amorphous disparity among iron oxides. Mineralogical composition revealed the predominance of the carbonate rock sectors with combination of quartz. Additionally, evaporites minerals, chert, flint, mudstone, igneous rocks, metamorphic rocks, and mud and feldspar granules are present.

The soils were dominated by quartz, with a few Mica and Kaolinite minerals, and plagioclase. This will have the effects of reducing vegetation coverage, leading to soil erosion, pollutant soil in the oil fields study area (toxic gasses, solid waste). Soil degradation will have an impact on the ground, causing the soil erosion and the decrease in the covering vegetation.

3. Sampling and Methods

The soil selected was not under cultivation for three decades ago. Twenty-four soil samples of 0-15 cm depth were collected to determine soil characteristics using standard methods under salinity stress from calcareous soil of lower Mesopotamian plain of Iraq (Mouhamad et al., 2014). Classification of soil was identified via standard soil textural triangle established by the United States Department of Agriculture (USDA) (Soil Survey Staff, 1951).

Soil Electrical conductivity (EC) and pH were measured by using a conductivity meter and pH meter respectively (Rhoades, 1982). Organic matter was obtained by multiplying the content of organic carbon after determined by Van Bemmelen, factor (Page, 1982). The Total nitrogen was determined by micro-Kjeldahl digestion; Total P of the soil samples and content of exchangeable potassium (K), calcium (Ca) and magnesium (Mg) were analysed using Olsen & Sommers method (1982). An Atomic Absorption Spectrophotometer examined the sodium absorption ratio (SAR), sodium relative to calcium and magnesium in water extraction from saturated soil paste.

Elemental analysis, including (K, Ca, Na, and Mg), was examined using X-Ray florescence. 0.4-0.5g of a sample was dried at 200oC for 30 minutes in drying oven. The samples were crushed using a ball-milling unit and homogenous particle size to ensure the minimizing of the matrix effect error. Then pressed via hydraulic piston with pressure of 15 Ton/cm2 and diameter of tablets are 32 millimetres. The samples were analysed using X-Ray florescence depended on Rand data were analysed with SPSS 18.0 and Microsoft Office Excel. Soil-physicochemical properties and K-factor data for normality were evaluated prior to regression analysis with the Kolmogorov-Smirnov test. The bivariate relationships between the measured K-factor and soil properties were determined with the Pearson correlation to detect the soil characteristics that influence the soil erodibility factor of the study area. To develop an equation to estimate the K factor based on the efficient soil properties, a stepwise multiple regression analysis was used. The standard error of the calculation was calculated using the predicted and reported K values to test the precision of the equation depended on Bonill and Johnson (2012).

4. Results and Discussions

Soil Texture and Soil Salinity

The characteristics of the soil survey in this project are shown in Table 1. The study soil's texture was silty clay, silty clay loam, clay, and clay loam texture calcareous in the study area. In our study, clay soils revealed positive correlation between the SAR (ranges <21.2±3.3 to >42±5.6), phosphorus (21.36±0.8-10.93±1.11), and organic matter (0.65±0.31-0.46±0.24). This reflects on building and accumulating of organic carbon that ranges from < 1.25±0.54 to > 0.93±0.45) or decomposing (FAO, 2006). However, there was lack of microbiological activity of urease enzyme with value of 140±15.1-67.9±7.3 potentially due to low nitrogen value that ranges from 0.48±0.27 to 0.13±0.09 and pH (8±0.41-7.4±0.31) with an increase of EC (23.1-74 -74±8.2).

Furthermore, silty clay loam soil was observed that conflicting behavior on clay soil texture. The silty clay loam soil showed negative correlations between SAR, P, and OM with values (78.75±8.7-210.27±23.5), (18.3±1.9-12.09±1.3), and (0.78±0.37-0.7±0.34), respectively. The negative relationship indicates the reduction in the organic carbon values that reached from 0.73±0.36 to 0.27±0.14. However, the positive correlation of urease activity ranges from46.94±5.1 to 120.44±13.4, with high salt concentration (20.6±3.7-64.09±5.9). This finding explains that microbial biomass and greater stabilization of extracellular urease are impacted by soil properties (Kujur and Patel,2014) such as pH (7.7±0.48-7.92±0.38) and N content (0.35±0.15-0.4±0.21).

In silt clay soil, overall accumulation of organic carbon (0.41±0.22-0.52±0.24) and OM (0.58±0.29-0.7±0.34) was similar behavior comparing to other soil texture. When the SAR ratio was high (27.2±3.8-49.2±5.7), the soil texture played an important role in the accumulation of organic carbon (Mohamad et al., 2018); while high SAR had a curved response with P (40.99±3.5-9.91±0.9), pH (8.63±0.54-8±0.45), N(0.36±0.15-0.32±0.14), and urease activity enzyme (92.44±10.1-101.19±11.0). This indicates an inhibition of enzyme activity reduced when soluble slats were increased from antagonism and homogenates participated in the active site of the urease enzyme (Macomber et al., 2015).

Compact clay loam-based soils are less prone to erosion comparing with loosely bound soil texture. Organic materials, in clay loam texture, decreased with increasing SAR values ranging from 17.72±2.7 to 49.26±5.8. This behavior found in the urease activity enzyme recorded values from 92.44±10.1-160.69±17.4.

However, the organic matter is the main sorbent for elements in the surface horizons of the soils. Therefore, the solubility of ions is the most significant influence of salinity and is ideal for the P (12.48±1.8-18.07±1.9), N (0.23±0.1-0.46±0.24), and OC (0.07±0.02-1.21±0.89). More heavy elements are soluble at low pH (7.1±0.39-8±0.45). As a result, pH values are considered a controlling agent and play an important role in fluctuations of pH from medium salinity soil to slightly alkaline to highly salinity soils (Shahid et al., 2018).

Erosion rate impacts significant deeply soil texture productions. Thus, the ratio of silt, loam and clay particles in the soil (Hossain and Nuruddin, 2016) and has a notable influence on causing different infiltration rates and variations in the ease of particle detachment affecting on clay level (Wei et al., 2019). The high-level of salinity causes to the study area to become a desert environment. This means the preliminary situation of aeolian effects is more evident (Saysel and Barlas, 2001). Sabkha dunes and sand sheets are the major wind formed deposits in the area. This situation developed an ideal example of how desertification is acting in the study area where there is lack of vegetation covered for three decades ago (Feng, 2015).

Soil pH

Soil pH plays an important role in soil health such as microorganisms' activity, plant growth, solubility, and absorption of colloids (Brady & Weil, 2004). Availability of nutrients depends on soil pH. Different plants require specific pH; however, 6.0 to 7.5 is a range of pH that allows adequate nutrients to be in a soil. Soil pH of the selected soil samples from Mesopotamian agricultural plain, Iraq, ranged from 7.1 to 8 with an average 7.84. Most of soil pH is moderate to basic soil pH based on standard of Boyed et al., (2004) (Table-2). High amount of salt causes the soil samples to be basic soil and not able to obtain adequate nutrients. As a result, the pH values of soil samples, in the current study, indicated that a soil degradation had occurred in the Mesopotamian agricultural plain of Iraq.

Table 1. Soil pH classification

Soil Texture	Soil pH	Type
Clay	7.4	Moderate basic
Clay	8	Basic
Silty clay loam	7.92	Basic
Silty clay loam	7.7	Moderate basic
Silty clay	8	Basic
Silty Clay	8.6	Basic
Clay loam	8	Basic
Clay loam	7.2	Moderate basic

Source: Boyed et al. (2004)

Soil Dispersive Property and Soil Electrical Conductivity (EC)

The data presented in the table provides information on the properties of different soil types. The soil texture is indicated in the first column, while the other columns contain various measurements, including electrical conductivity (EC), pH, phosphorus (P), sodium (Na), magnesium (Mg), calcium (Ca), sodium adsorption ratio (SAR), urease activity, nitrogen content (N%), organic matter content (OM%), and organic carbon content (OC%). The values are presented as means ± standard deviations. According to the data, there are four distinct soil textures: Clay, Silty clay loam, Silty clay, and Clay loam. Each soil texture is represented by two rows of data. The electrical conductivity (EC) values range from 20.1±3.1 ds/m to 74±8.2 ds/m, while the pH values range from 7.1±0.39 to 8.63±0.54. The phosphorus (P) values range from 9.91±0.9 ppm to 40.99±3.5 ppm. The sodium (Na), magnesium (Mg), and calcium (Ca) values vary significantly between different soil textures and within the same soil texture. The sodium adsorption ratio (SAR) values range from 17.72±2.7 to 210.27±23.5, while the urease activity values range from 0.13±0.09 µg NH4-N g-12h-1 to 0.48±0.27 µg NH4-N g-12h-1. The nitrogen content (N%) values range from 0.23±0.1% to 0.48±0.27%, while the organic matter content (OM%) values range from 0.07±0.02% to 1.25±0.54%. The organic carbon content (OC%) values range from 0.27±0.14% to 1.21±0.89%. This data provides valuable insights into the properties of different soil types and can be useful for further analysis and research. The results of organic matter and Sodium Adsorption Ratio of soil samples in Mesopotamian agricultural plain, Iraq, were from 0.35 % to 0.94 % with an average 0.6 % and from 17 to 210 with an average 61.95, respectively (Table 1). The critical thresholds of OM and SAR are 2 % and 15, respectively. The OM % and SAR were below the critical threshold in the selected soil sample in the study area. This means the soil samples suffer physico-chemical breakdown once they are exposed to water. Electrical conductivity ranged from 20.1 ds/m to 64.09 ds/m with an average 42.84 ds/m (Table-1). Plotting SAR and Electrical Conductivity (EC) reveals dispersity characteristics of soil (Rengasamy et al., 1984). Our data shows all of soil samples have a dispersive property (Figure 1). Therefore, the soil samples are vulnerable to soil erosion by water.

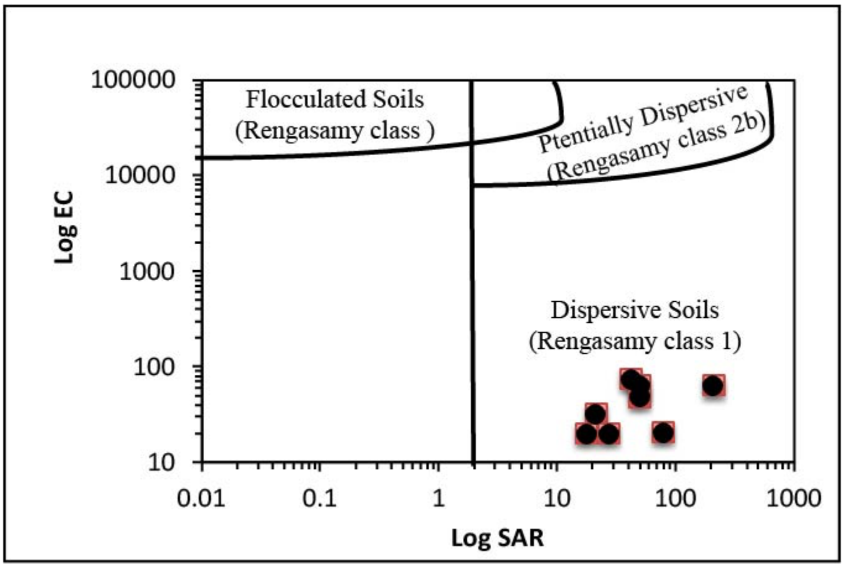


Figure 1. Dispersive property of soil sample

Source: Source: Mouhamad R., 2024

Soil electrical conductivity (EC) is a measurement of soil salinity. It is considered very important indicator of soil health. Microorganism activity decreases as salt concentration increases in soil leading to impact soil processes such as respiration, nitrification, and denitrification. The electrical conductivity values of selected soil samples in the study area were too high based on classification of EC soil by Chowdhury et al., (2011). The minimum value was 20.1 ds/m, while maximum value was 74 ds/m with an average 42.84 ds/m. Due to the lack of runoff water and high temperature in the area, salinity of soil increases as result of evaporation of surface water and shallow groundwater.

The high amount of salt in the soil samples indicates the presence of soil damaged due to lack of precipitation, increase evaporation rate, and lack of vegetation covered and top of all these the area has not been farmed for three decades.

Table 2. Physiochemical parameter of soil samples from Iraqi Flora Land sites.

Texture	EC (ds/m)	pH	P (ppm)	Na (ppm)	Mg (ppm)	Ca (ppm)	SAR	Urease NH_4-N (g-12h-1)	N (%)	OM (%)	OC (%)
Clay	74±8.2	7.4±0.31	21.36±0.8	15726±998.4	3884±400.1	4226±263.1	42±5.6	67.9±7.3	0.13±0.09	0.65±0.31	1.25±0.54
Clay	23.1±11.3	8±0.41	10.93±1.11	4072.7±945.7	1009±112.1	1136±158.2	21.2±3.3	140±15.1	0.48±0.27	0.46±0.24	0.93±0.45
Silty clay loam	64.09±5.9	7.92±0.38	12.09±1.3	32990±968.4	832.3±88.9	474.2±55.2	210.27±23.5	120.44±13.4	0.4±0.21	0.36±0.18	0.27±0.14
Silty clay loam	20.6±3.7	7.7±0.48	18.3±1.9	9173±911.7	339.3±45.1	460.4±51.4	78.75±8.7	46.94±5.1	0.35±0.15	0.78±0.37	0.73±0.36
Silty clay	48.6±3.9	8±0.45	9.91±0.9	12667±789.4	2112±189.8	1548±168.2	49.2±5.7	73.19±8.2	0.32±0.14	0.7±0.34	0.52±0.24
Silty clay	20.1±3.1	8.63±0.54	40.99±3.5	4744.7±499.5	822±98.1	944±100.1	27.2±3.8	101.19±11.0	0.36±0.15	0.58±0.29	0.41±0.22
Clay loam	63.2±5.9	8±0.45	18.07±1.9	12931.4±250.7	2166±290.1	1646±178.2	49.26±5.8	92.44±10.1	0.46±0.24	0.39±0.18	1.21±0.89
Clay loam	20.1±3.1	7.1±0.39	12.48±1.8	3307.2±400.1	983.5±100.4	1017±150.4	17.72±2.7	160.69±17.4	0.23±0.1	0.94±0.51	0.07±0.02

Source: Source: Mouhamad R., 2024

Elemental Ratios Interaction and Soil Erosion

Elemental ratios are vital record of soil erosion interpretation. Calcium (Ca) and Magnesium (Mg) are slats that contribute to salinity. However, they do not increase soil dispersion like sodium due to their smaller particles compared with sodium and tend to be closer to clay particles. Consequently, Calcium (Ca) and Magnesium (Mg) can enhance soil structure by affecting the soil particles to carved apart for aeration and water drainage. Additionally, Ca and Mg keep soil flocculated which help decrease the dispersion of soil clays and consequently increase infiltration and decrease erosion rate (Warrence et al., 2003). Conversely, increase the concentrations of Ca and Mg might become toxic elements to plants. However, the presence of sodium (Na) soil physical property by casing soil dispersion to occur (Warrence et al., 2003). The ratios of Ca/Mg, Na/Ca, and Na/Mg of soil samples from the Mesopotamian planar plotted (Figure 3 & 4). The ratio of Ca/Mg of soil less than 2 and more than 6 is considered dispersive soil or poorly structured (Botta, 2015). Ca/Mg records of soil samples recorded from 39 to 83, which indicate the evidence of dispersive soil (Figure 2).

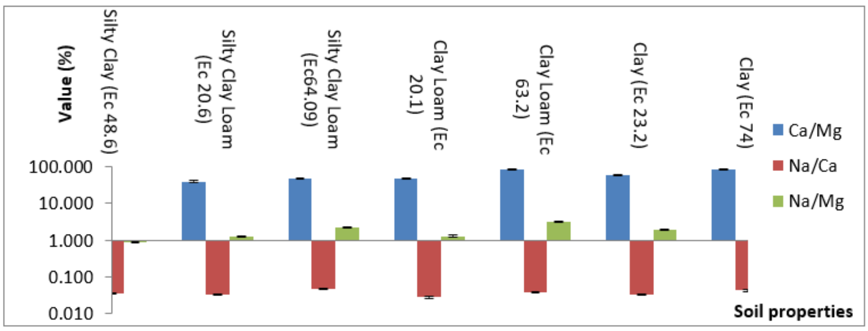


Figure 2. Relationships between soil texture, salinity and Ca/Mg, Na/Ca, and Na/Mg ratio. Error bars equal one standard deviation.

Source: Source: Mouhamad R., 2024

The main source of Ca and Mg in the study area is from carbonate especially dolomite [$CaMg(CO_3)_2$] (Ghalib, 2017). Ca/Mg and Na/Mg observed more significantly in clay> clay loam>silty clay loam>silly clay under high salinity, while the middle salinity observed in the clay > silly clay >clay loam> and silly clay (Figure 3).

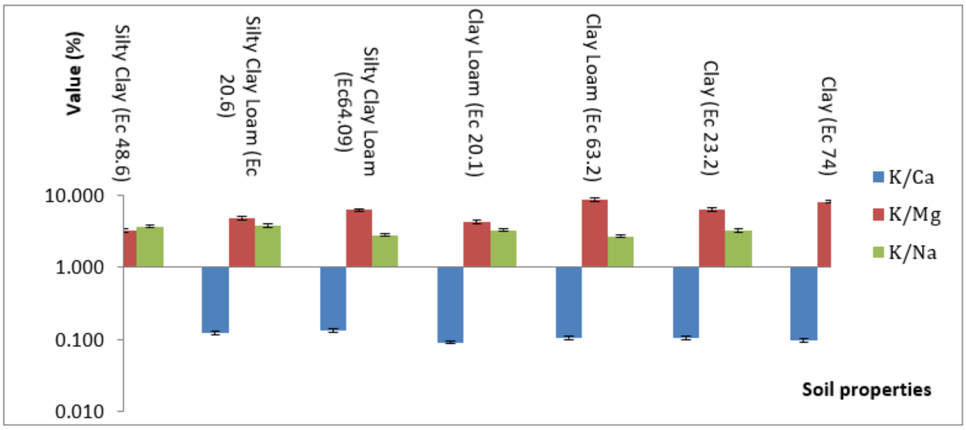


Figure 3. Relationships between soil texture, salinity and K/Ca, K/Mg and K/Na ratio. Error bars equal one standard deviation

Source: Source: Mouhamad R., 2024

The Ca/Mg in clay texture varied from 59.9 to 83.3 with salinity invested. The Ca/Mg of clay loam was significantly higher than those of the silty clay and silty clay loam. Also, Na/Ca was no significant ratio in all types of texture soil, have a more dominant effect on the structure and can cause them to bind together. It is the balance between the two that results in well-structured soil (Totsche et al., 2017).

K/Ca, K/Mg and K/Na ratios with different soil salinity and texture plotted (Figure 4). High levels of Ca impact and reduce the amount of K in soil. In the area of the study, high Ca content in soil samples reduced K/Ca ratios. The K/Ca ranged from 0.09 to 1.3 and no significant difference was found between the soil textures. Whereas the K/Mg and K/Na ratio increased with clay counted. Increasing of K/Mg ratio of clay soil indicates that a significant amount of Mg. The K/Mg varied from 8.1 to 3.2 in clay and silty clay respectively. Application of K from the farmers increased the K/Mg ratio; Negative effects of Mg applied with magnesium carbonate on soil structure are well established for sodic soils. This could potentially possibly reason for an erosion and sedimentation (Dontsova and Norton, 2002; Dontsova et al., 2004).

Soil Erodibility Factor

Soil erodibility factor (K-factor) is quantitative measurement to estimate the inherent erodibility of soil by either rainfall or runoff. There are several factors impact the rate of erodibility such as infiltration rate, permeability, total water capacity, dispersion, rain splash, abrasion and calcium content. The range of soil erodibility is from lowest erodibility0.02 to high erodibility0.69 (Goldman et al. 1986; Mitchell and Bubenzer, 1980).

The high value of K means a soil is more susceptible to erosion by rainfall or runoff. In general, lower K value indicates low risk of soil erosion due to high content of organic matter, greater permeability, and improved soil structure. High value of K could happen as the presence of silt, very fine sand, and clays; while a soil with sand, sandy loam, and loam texture tends to be less erodible. The functional RUSLE equations are used for soil erosion based on physicochemical soil traits such as the soil texture, the composure of soil, consistency of soil organic matter (Bonilla and Johnson, 2012), and characterization of soil eroding on table 3 and map 2 and 3.

Table 3. The RUSLE K- factor correlation matrix and soil properties

Soil Properties	Sand	Silt	Clay	OM%	SAR	K factor
Sand	1					
Silt	0.271656*	1				
Clay	-0.83614***	-0.75503***	1			
OM%	0.019093	-0.27673*	0.144713	1		
SAR	0.685032***	0.177326	-0.56779**	-0.46099**	1	
K factor	0.42921**	-0.37423**	-0.07914	0.397613**	0.00629	1

Source: Source: Mouhamad R., 2024

The K factor is high correlated significantly with the sand ($p<0.01$) and organic matter at $p<0.01$, while the K factor decreased surprisingly with silt at < 0.01 due to the high content of calcium. Table 3 indicates that the clay content of soil and the sodium absorption ratio did not exhibit critical behaviours; that it confirms the fact that salt erosion is not a significant cause of erosion and there is no reduction or rise in the concentration of sediment in erosion-prone areas. The SARs are significantly correlated with sand ($p < 0.001$); clay ($p<0.01$) and OM ($p<0.01$).

The study area in the southwestern part of the governorates of Waist is clearly located East of Iraq, and it has the advantages of being located on the sedimentary plain northeast which dates to its fourth deposits in terms of its origin and geological form. This gives the advantage of its location; have low quantities of organic and high amounts (calcite, aragonite and dolomite) carbonates in most of the soils located in the semi-arid regions. Therefore, significant erosion changes need to focus on climate change again (Shahid et al., 1999; 2018).

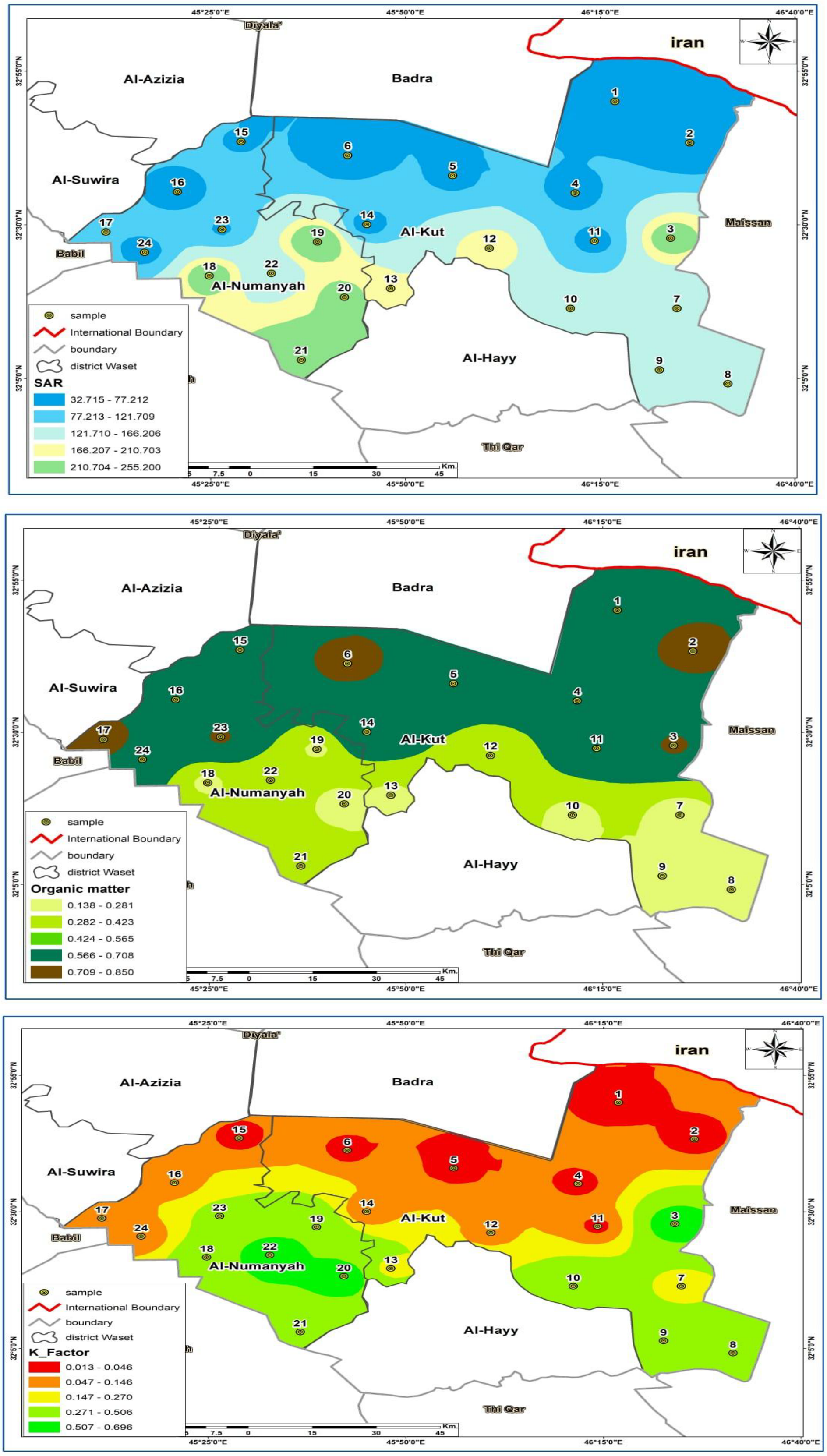
Many model parameters were studied to choose the model that best fits the study area for each of soil erodibility and soil properties. Table 4 shows summaries of the sample statistics for the soil texture (clay, sand, silt), grain size, the OM contents produced from random sampling of the full geopedological area map data and the normal distribution of the erodibility factor (Map 2;3).

Table 4. The RUSLE K- factor correlation matrix and soil properties

	Clay	Clay	Silty clay loam	Silty clay loam	Silty clay	Silty clay	Clay loam	Clay loam	Mean	Standard Deviation	Kurtosis	Skewness	Confidence Level (95.0%)
Sand	8.3	6.6	20.7	21.7	6.8	6.5	13.5	14	12.263	6.2749	-1.2996	0.6555	5.2459
Silt	46.6	56.8	49.3	50.6	42	40	45.9	45.2	47.05	5.2492	0.6795	0.653	4.3885
Clay	45.1	36.6	30	27.7	51.2	53.5	40.6	40.8	40.688	9.21	-1.0251	-0.0314	7.6998
OM (%)	0.65	0.46	0.36	0.78	0.7	0.58	0.39	0.94	0.6075	0.2006	-0.7417	0.3321	0.1677
K factor	0.0128	0.0102	0.0157	0.0165	0.0105	0.0184	0.0159	0.0216	0.0152	0.0039	-0.5845	0.1657	0.0033

Source: Mouhamad R., 2024

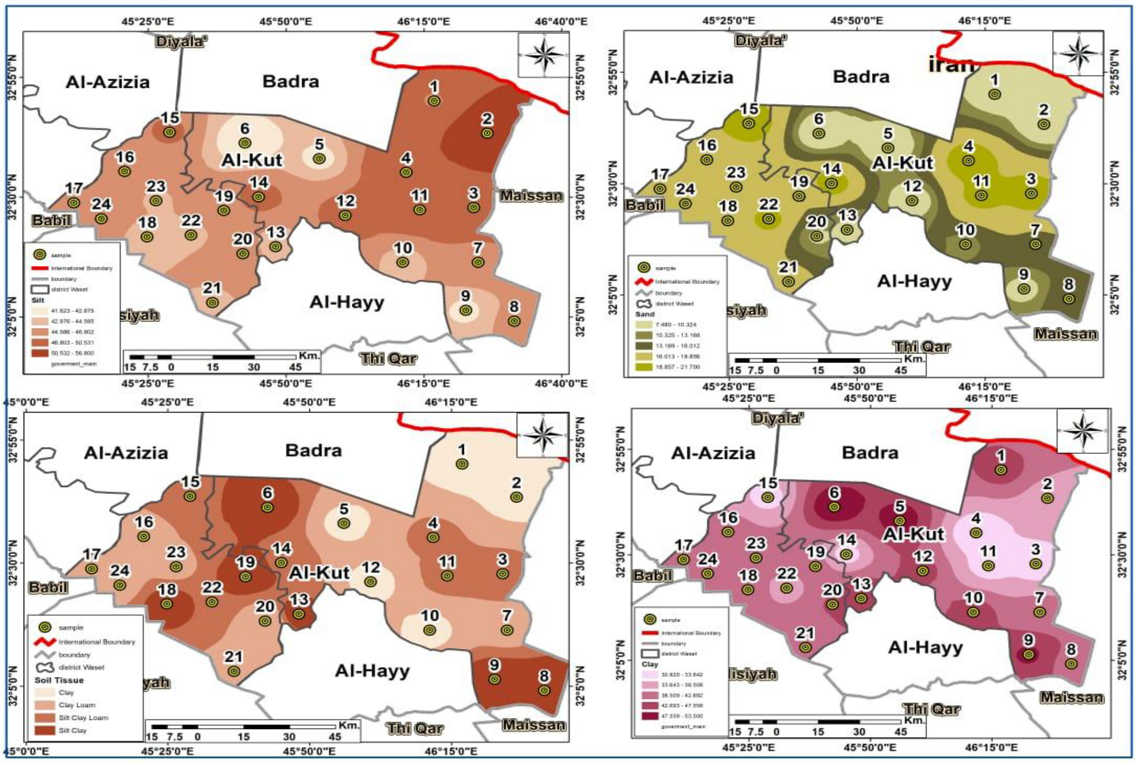
Mesopotamia sediment: clay: 41-57%, silt: (37-53)0%; sand: (1-13) %, gravel: none.



Map 2. Arc map of Organic matter, SAR, and K factor.

Source: Source: Mouhamad R., 2024

Each covered a large and flat area with no vegetation, covered by fine, fine grounds, sediment accumulated in high surroundings over a very long time, overflowing in very long periods. In study area the percentage of the silt in the eastern part of the study area increases and decreases in the south, while the proportion of clay in the north and south of the area of the study rises, whereas sand is widened across the region and the dominant tissue texture in the southern part is alluvial clay and mixture clay (Map 3).



Map 3. Arc map of Organic matter, SAR, and K factor

Source: Source: Mouhamad R., 2024

Table 3 contains data on the properties of different soil types, including their sand, silt, and clay content, organic matter content (OM%), and K factor. The first row indicates the soil texture, and the other rows contain various measurements. The values in the table are given as means for each soil texture, with the last four columns providing the overall mean, standard deviation, kurtosis, and skewness for each property.

From the data, it appears that there are four different soil textures: Clay, Silty clay loam, Silty clay, and Clay loam. For each soil texture, there are two rows of data. The sand content values range from 6.5 to 21.7, with a mean of 12.263 and a standard deviation of 6.2749. The silt content values range from 40 to 56.8, with a mean of 47.05 and a standard deviation of 5.2492. The clay content values range from 27.7 to 53.5, with a mean of 40.688 and a standard deviation of 9.21.

The organic matter content (OM%) values range from 0.36% to 0.94%, with a mean of 0.6075% and a standard deviation of 0.2006%. The K factor values range from 0.0102 to 0.0216, with a mean of 0.0152 and a standard deviation of 0.0039.

This data provides valuable insights into the properties of different soil types and can be useful for further analysis and research. Most measurements of the slim and silt ranged with a mean value of sand 12.26% and an average value of OM 0.607, which differed between 47.05 and 40.68 clay; about 0.0033 and 7.699 percent of the strong heterogeneity coefficient. Skews and Kurtosis range between -0.0314 and 0.1657. The factors are therefore quite distorted by standard deviation; do not match the definition of normality. It is obvious that the organic matter is declining in the southeastern parts, as shown in terms of salt extent in the southerner part by the erosion and corrosion processes, as the organic matter declines in the southerner part, corresponding to an increased corrosion factor arranged 0.147-0.696 (Table 4 and Map 3).

The table provided shows the correlation coefficients between different soil properties, including sand, silt, clay, organic matter content (OM%), sodium adsorption ratio (SAR), and K factor. The correlation coefficients indicate the strength and direction of the linear relationship between two variables. A correlation coefficient of 1 indicates a perfect positive linear relationship, while a correlation coefficient of -1 indicates a perfect negative linear relationship. A correlation coefficient of 0 indicates no linear relationship between the two variables. From the data, it appears that there is a strong negative correlation between sand and clay content ($r = -0.83614$, $p < 0.001$), indicating that as sand content increases, clay content decreases. There is also a strong negative correlation between silt and clay content ($r = -0.75503$, $p < 0.001$), indicating that as silt content increases, clay content decreases. There is a moderate positive correlation between SAR and sand content ($r = 0.685032$, $p < 0.001$), indicating that as SAR increases, sand content also increases. There is also a moderate negative correlation between SAR and clay content ($r = -0.56779$, $p < 0.01$), indicating that as SAR increases, clay content decreases. There is a weak negative correlation between OM% and silt content ($r = -0.27673$, $p < 0.05$), indicating that as OM% increases, silt content decreases. There is also a weak positive correlation between K factor and sand content ($r = 0.42921$, $p < 0.01$), indicating that as K factor increases, sand content also increases.

These correlations provide valuable insights into the relationships between different soil properties and can be useful for further analysis and research. Improvements and related management of soil resources in localized areas can typically affect soil resources but can vary according to the amount of change based on manpower control. The key considerations that affect land use and transformation such as growing crops and houses, unsecured land ownership, soil quality, and other aspects are defined by land management systems (Mekonnen, 2018).

5. Conclusions

Physical and chemical analysis of soil samples, from Mesopotamian agricultural plain/Iraq, determined changes in soil properties due to climate change. High amount of salt causes the soil samples to be basic soil and not able to obtain adequate nutrients which are essential for growing food. Plotting SAR and Electrical Conductivity (EC) indicated the soil samples are vulnerable to soil erosion by water. The elemental ratios indicated the lack of potassium (K), which is essential for growing food, due to the high concentration of calcium (Ca). Soil erodibility factor recorded low values due to the high concentration of Ca. Overall, the soil in Mesopotamian agricultural plain, located in Iraq is damaged and not adequate to grow food. The soil needs to be managed restored before it is too late.

References

1. Al- Maliki, M. A. S. (2005). Evaluation of air pollutants, water and soil in the city of Baghdad, using geographic information system (GIS), PhD thesis, Faculty of Science, Baghdad University, pp:171.
2. Al Saedi J. K.; Ramla D. A.; N. M. H. (2018). Determination the Concentration Elements of Cultivation Media (Peat Moss, Perlite and Hormone) Using X-ray Fluorescence Technique. Iraqi Journal of Science, 2018, Vol. 59, (4A): 1769-1777.
3. Al-Falahi, A. A. and A. S. Qureshi, (2012), The relationship between groundwater table depth, groundwater quality, soil salinity and crop production. Technical Report 4. Soil salinity Project in central and southern of Iraq. International Center for Agricultural Research in Dryland Areas (ICARDA), Aleppo, Syria.
4. Al-Qaraghuli, N. (2005). Content of nutrients (total, water soluble and available) in the fertilizers produced from Al-Kaim-Iraq. The Iraqi Journal of Agricultural Sceinces.36 (5):35-42.
5. AL-Salihi A. M. and Hassan Z. M. (2015). Temporal and Spatial Variability and Trend Investigation of Total Ozone Column over Iraq employing remote sensing Data: 1979–2012. International Letters of Chemistry, Physics and Astronomy. 53:1-18. Astronomy Online: 2015-07-01 ISSN: 2299-3843, Vol. 53, pp 1-18 d.
6. Ardakani, A.J., Zahirinia, A.R., (2006). Effects of gypsum application in different unstable slopes on surface runoff and soil erosion. Paper presented at the 18th World Congress of soil science, 9-15 July 2006, Philadelphia, Pennsylvania, USA.
7. Aswood M. S. (2017). Determination of Heavy Metals in Fertilizer Samples by X-ray Fluorescence Techniques. J. of Uni. of Babylon, Pure and Applied Sci., Vol.25 (5);1778-1785.
8. Bonilla C & Johnson O. (2012). Soil erodibility mapping and its correlation with soil properties in Central Chile. Geoderma, Volumes 189–190, November 2.
9. Botta, Cath, (2015), Soil Test Step By Step. Yea River Catchment Landcare Group. P. 49.
10. Blum, W. E., 2005. Functions of soil for society and the environment. Reviews in Environmental Science and Bio/Technology, 4, 75-79.
11. Chibowski E. (2011). Flocculation and dispersion phenomena in soils, in: Encyclopedia of Agrophysics, J. Glinski, J. Horabik, J. Lipiec (Eds.), Springer, p. 301–303. DOI: https://doi.org/10.1007/978-90-481-3585-1_59.
12. Dontsova, K. M., and L. D. Norton. (2002). Clay dispersion, infiltration, and erosion as influenced by exchangeable Ca and Mg. Soil Sci. 163:184-193. DOI: 10.1097/00010694-200203000-00003.
13. Dontsova, K. M., L. D. Norton, C. T. Johnston, and J.M. Bigham. 2004. Influence of exchangeable cations on water adsorption by soil clays. Soil Sci. Soc. Am. J. 68:1218–1227. DOI: 10.2136/sssaj2004.1218.
14. DWRW (Directorate of Water Resources in Wasit). (2010). Unpublished report, Ministry of Water Resources, Republic of Iraq.
15. El-Taher, A., &Althoyaib, S. S. (2012). Natural radioactivity levels and heavy metals in chemical and organic fertilizers used in Kingdom of Saudi Arabia. Applied Radiation and Isotopes, 70(1), pp. 290-295.
16. Essa, S.K. and D.A.Al-jibury. 2017. Heavymetals pollution for soils in some of roads andsquares of Baghdad city center. The IraqiJournal of Agricultural Sciences. 48(6):1456-1472.

17. Ewaid, S.H.; Abed, S.A.; Al-Ansari, N. (2029). Footprint of Wheat in Iraq. Water, 11, 535. https://doi.org/10.3390/w11030535
18. FAO. (2015). World Soil Charter. Rome: Food and Agriculture Organization of the United Nations.
19. FAO. (2016). Voluntary Guidelines for Sustainable Soil Management. Food and Agriculture Organization of the United Nations. Rome, Italy.
20. FAO. (2003). Towards sustainable agricultural development in Iraq: The Transition from Relief, Rehabilitation and Reconstruction to Development. 222 pp.
21. FAO. (2006). World reference base for soil resources 2006. A framework for international classification, correlation and communication. Rome, FAO.
22. Feng, Q., Ma, H., Jiang, X. M., Wang, X. & Cao, S. X. (2015). What has caused desertification in China? Sci. Rep. 5, 15998. DOI:10.1038/srep15998.
23. Ghalib, H. B. (2017). Groundwater chemistry evaluation for drinking and irrigation utilities in east Wasit province, Central Iraq. Appl Water Sci 7:3447–67. doi:10.1007/s13201-017-0575-8.
24. Hassoon, H.A. (2017). Heavy metals contamination assessment for some imported and local vegetables. Iraqi J. of Agri. Sci. 49(5):794- 802.
25. Hossain, M. D. and Nuruddin, A. A. (2016). Soil and Mangrove: A Review. Journal of Environmental Science and Technology, 9: 198-207. DOI: 10.3923/jest.2016.198.207.
26. Hanna, A.A. and Al-hillale, M.A. (1986). Measurement and standardization of some pollutant elements in the Mesopotamian plain sediments-Iraq. GEOSURVE, int. rep. no. 1525.
27. ICBA (International Center for Biosaline Agriculture), (2003). Assessment of brackish and saline groundwater availability in selected countries in the West Asia and North Africa (WANA) region. Dubai, UAE. ICBA.
28. Kujur, M., Patel, A.K. (2014). Kinetics of soil enzyme activities under different ecosystems: An index of soil quality. Chil. J. Agric. Res. 74, 96–104. http://dx.doi.org/10.4067/S0718-58392014000100015.
29. Macomber L, Minkara MS, Hausinger RP, Merz KM Jr. (2015). Reduction of urease activity by interaction with the flap covering the active site. J ChemInf Model;55(2):354–361. doi:10.1021/ci500562t.
30. Mekonnen, Z. (2018). Observed and Projected Reciprocate Effects of Agriculture and Climate Change: Implications on Ecosystems and Human Livelihoods, Climate Change and Global Warming, Ata Amini, IntechOpen, DOI: 10.5772/intechopen.79118.
31. Morozova, G. (2005). A review of Holocene avulsions of the Tigris and Euphrates Rivers and possible effects on the evolution of civilizations in Lower Mesopotamia. Geoarchaeology, 20, 401–423. http://dx.doi.org/10.1002/gea.20057.
32. Mouhamad, R., Ayad G. Rasheed, Hind F. AL-Gburi. (2019). Predicting Soil Organic Carbon Turnover in Soils at the Middle Region of Iraqi Using Infrared Spectra. JJ Plant Biol; 4(1): 009. https://jacobspublishers.com › scientific_76_1429_28052019120335.
33. Mouhamad, R. S., Alsaede, A. and Munawar I. (2015). Decomposition of organic matter under different soil textures. Current Science Perspectives; 1(1):1-4. https://www.researchgate.net › publication › 277775445_Decomposition_of
34. Mouhamad, R. S., Ibrahim B. Razaq, Ali S. Fadhel, A., Shaimaa A. Yousir, Dhrgham I. Taha and Munawar I. (2014). Urease activity under salinity stress in calcareous soils of semi-arid regions of Iraq. IJCBS, 6:68-71 www.iscientific.org › wp-content › uploads › 2018/02 › 10-IJCBS-14-06-21.

35. Nidal A. and Amel M. N. (2016). Mineralogical and Heavy Metal Assessment of Iraqi Soils from Urban and Rural Areas. 2016.J. of Al-Nahrain Uni.; Vol.17 (2); 55-63.
36. Olsen, S.R. and Sommers, L.E. (1982). Phosphorus. In: Page, A.L., Ed., Methods of Soil Analysis Part 2 Chemical and Microbiological Properties, American Society of Agronomy, Soil Science Society of America, Madison, 403-430.https://dl.sciencesocieties.org
37. Orita, N., (2012). Root uptake of organic contaminants into plants: species differences. All Graduate Theses and Dissertations. Paper 1287. Utah State University. Page
38. Page, A. L., Miller, R. H. and Keeney, D. R. (Eds.) (1982). Methods of soil analysis; 2. Chemical and microbiological properties, 2. Aufl. 1184 S., American Soc. of Agronomy (Publ.), Madison, Wisconsin, USA, Gebunden 36 Dollar.
39. Pierzynski, G.M., Sims, J.T. and Vance, G.F.(2005). Soils and Environmental Quality, Third Edition. Taylor and Francis, Boca Raton, FL. 569 p.
40. Qureshi, A. S., Ahmad, W., & Ahmad, A. F. A. (2013). Optimum groundwater table depth and irrigation schedules for controlling soil salinity in central Iraq. Irrigation and Drainage, 62(4), 414-424.
41. Qureshi, A.S. (2014). Reducing carbon emissions through improved irrigation management: A case study from Pakistan. Irrig. and Drain. 63: 132-138.
42. Rahi, K. A. and Halihan, T. (2010). Changes in the Salinity of the Euphrates River System in Iraq," Regional Environment Change, 10(1): 27-35.
43. Rauof, A, Hammud, K, Ahmed A, Thabit. (2014). Elemental analysis of commercial fertilizers in Iraqi market, Arch. Appl. Sci. Res.; 6(5): 90-95.
44. Rauof, A, Hammud, K, Kafa K. H.; Duraid E. Z.; Faris N. A.; and Huda A. K. (2015). Flame Atomic Absorption (FAAS) and X-RayFluorescence (XRF) spectroscopic. Elemental Analysis of Commercial Fertilizers in Iraqi Market.IJAPBC – Vol. 4(4): 494-800
45. Rhoades, J. D. (1982). Soluble salts. p. 167-179. In: A. L. Page et al. (ed.) Methods of soil analysis: Part 2: Chemical and microbiological properties. Monograph Number 9 (Second Edition). ASA, Madison, WI.
46. Saysel, A. K., & Barlas, Y. (2001). A dynamic model of salinization on irrigated lands. Ecological Modelling, 139, 177–199.DOI: 10.1016/S0304-3800(01)00242-3.
47. Shahid S.A., Zaman M., Heng L. (2018). Introduction to Soil Salinity, Sodicity and Diagnostics Techniques. In: Guideline for Salinity Assessment, Mitigation and Adaptation Using Nuclear and Related Techniques. Springer, Cham. 1-42. DOI. https://doi.org/10.1007/978-3-319-96190-3_1.
48. Shahid, S.A., Taha FK, Abdelfattah, M.A. (1999). Developments in Soil Classification, Land Use Planning and Policy Implications. Springer Dordrecht Heidelberg NY London. DOI 10.1007/978-94-007-5332-7.
49. Soil Survey Staff. (1951). Soil Survey Manual. USDA, Soil Conservation Service, Agricultural Handbook No. 18, U.S. Gov. Print. Office, Washington, D.C. 437 pp.
50. Spaargaren, O. (2001). Major Soils of the World. Wageninen, The Netherlands: International Soil Reference and Information Centre. indico.ictp.it › event › contribution › material › 0.pdf.
51. Tangahu, B.V., Adbullah, S.R.S., Basri, H., Idris, M., Anuar, N. & Mukhlisin, M. (2011). A review on heavy metals (As, Pb, andHg) uptake by plants through phytoremediation. International Journal of Chemical Engineering, Volume 2011, Article ID 939161, 31 pages

52. Tóth, G., Hermann, T., Da Silva, M.R. &Montanarella, L. (2016). Heavy metals in agricultural soils of the European Union with implications for food safety. Environment International, 88: 299-309.
53. Totsche, K.U., Amelung, W.; Gerzabek, M. H.; Guggenberger,G.; Klumpp, E.; Knief, C.; Lehndorff, E., Mikutta, R.; Peth, S.; Prechtel, S.; Ray, N.; and Kögel-Knabner, I. (2017). Microaggregates in soils J. Plant Nutr. Soil Sci., 181 (1): 104-136. DOI:10.1002/jpln.201600451.
54. Vargas, R., Achouri, M., Maroulis, J., & Caon, L. (2016). Healthy soils: a prerequisite for sustainable food security. Environmental Earth Sciences, 75(3), 180. https://doi.org/10.1007/s12665-015-5099-7.
55. Wei, Y., Wu, X., Xia, J., Zeng, R., Cai, C., & Wang, T. (2019). Dynamic study of infiltration rate for soils with varying degrees of degradation by water erosion. International Soil and Water Conservation Research, 7(2), 167–175. https://doi.org/10.1016/j.iswcr.2018.12.005.
56. Wu, W., W.M. Al-Shafie, A.S. Mhaimeed, F. Ziadat, V. Nangia, and W. Payne. (2014). Salinity mapping by multiscale remote sensing in Mesopotamia, Iraq. IEE Xplore Digital Library 99: 1–11.
57. Yaron, B., Dror, I., & Berkowitz, B. (2012). Soil-Subsurface Change. Chemical Pollutants Impacts. Berlin: Springer.doi:10.1007/978-3-642-24387-5.
58. Yashim, Z.I., Israel, O.K. & Hannatu, M. (2014). A study of the uptake of heavy metals by plants near metal-scrap dumpsite in Zaria, Nigeria. Journal of Applied Chemistry. Volume 2014, Article ID 394650.