حساب مخزون الكربون العضوي ومكوناته الفعالة في بعض الترب العراقية تحت نظم استخدام مختلفة باستخدام موديل Roth-C

Accounting Soil Organic Carbon Stock and Its Active Components in some Iraqi Soils under Different Land Use Practices Using Roth-C Model

Ahmad S. Muhaimeed(1-2) **Daniel D. Dale**(3)

(1) Land Management and Water uses Dept.- The Arab Center for the Studies of Arid Zones and Dry lands (ACSAD)/Syria.
(2) Soil Sciences and Water Department, Baghdad University, Iraq.
(3) Land Management and Tenure, Officer, FAO.

profahmad1958@yahoo.com

الملخّص

نفذت الدراسة بهدف حساب مخزون الكربون العضوي ومكوناته الفعالة باستخدام موديل Roth- C في ترب بعض الحقول الواقعة تحت أنظمة استخدام متنوعة متكونة من دورات زراعية تشمل زراعة المحاصيل، وتتضمن قمح - بور، وذرة - بور، وشعير - بور، وحشائش طبيعية طويلة واشجار الغابات في كل من المناطق الجبلية والأهوار في العراق. تم اختيار عشرة حقول في مناطق مختلفة ممثلة للاستخدامات الشائعة، ومنها النباتات الطبيعية، والأراضي المتروكة، والأراضي الزراعية تحت ظروف مناخية متنوعة. جمعت المعلومات للمواقع، وأخذت عينات تربة من المواقع المختارة، وتم تقدير الصفات العامة للترب مخبرياً اعتمادا على استخدام طرائق التحليل الشائعة. أشارت النتائج إلى وجود تأثير لنوع استخدام الأراضي في الصفات العامة للترب، ولاسيما محتوى الكربون العضوي، إذ تراوح محتوى الطين بين 18.1 % في ترب الحقول المروية في بابل (Bab 2)، و55.9 % في ترب مناطق الزراعة الجافة (غير المروية) في أربيل (Erbil 1)، مع وجود تأثير لخصائص التربة المدروسة في تراكم المواد العضوية ومكوناتها الأساسية. سجلت ترب النباتات الطبيعية أعلى محتوى للكربون العضوي ومكوناته. اشارت الحسابات التنبؤية باستخدام الموديل Roth-C إلى أن الكربون العضوي للترب المدروسة يتكون من:

of 0.45% C in RPM, 2.0% C in DPM, 7.97% C in IOM,13.24% in Bio and 76.36% in HUM.

وأن ترب النباتات الطبيعية احتوت على أعلى محتوى من الكربون العضوي الكلي (TOC)، وأعلى محتوى من الكربون الكروي وغاز ثاني أوكسيد الكربون المفقودة من ترب الحقول. وبينت النتائج وجود استجابة كبيرة لتطبيق الموديل Roth لحساب كمية الكربون العضوي الكلية ومكوناته الفعالة في بعض الترب تحت أنظمة زراعية مختلفة مقارنة بكميات الكربون العضوي المقدرة بالطرائق الاعتيادية.

الكلمات المفتاحية: الكربون العضوي الكلي (TOC)، موديل Roth-C، غاز ثاني أوكسيد الكربون (CO_2).

Abstract

This study was conducted to compute organic carbon stock and its components using the Roth-C model in the soils of some selected farms under different land use systems comprising crop- fallow rotation including wheat- fallow, maize - fallow, Barley-fallow, native vegetation of tall grasses and forest in the mountain and marshland area. The predominant grass species are Panicum, Coloniao and reed in the marshlands. Ten farms were selected from different locations representing common land use that include native vegetation,

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bare land and cultivated land and under different climatic conditions. General surface data were collected about all selected location and soil samples were taken to determine general soil properties using the common laboratory methods. The results revealed the effect of land use type on the common soil properties mainly the total organic carbon(TOC). Clay content ranged from 18.1% in the soil of babel in irrigated farm (Bab 2), to 55.9% in the soils of Erbil under dry farming system. The results show some variations in soils properties which affect organic matter accumulation and its components. Soils of the native vegetation show the highest content of TOC and its components. The Roth-C model predicts that the soil organic carbon consists of 0.45 % C in RPM, 2.0 % C in DPM, 7.97 % C in IOM, 13.24 % in BIO and 76.36% in HUM. Soils of the native vegetation show the highest content of TOC and have the highest amount of OC lost and CO_2 evolved from the farms. According to these results, the application of Roth – C model responded well to predictions for TOC and its components in some Iraqi soil under different land uses, compared with measured values of TOC in some of the farms.

Key words: Organic carbon (TOC), Roth - C model, CO_2.

Introduction

The term soil organic matter (SOM) is used to describe the organic constituents in soil in various stages of decomposition such as tissues from dead plants and animals, organic materials less than 2 mm in size, and soil organisms. The amount of SOM in the soil expresses the relationships between the sources of organic materials and the decomposing factors (soil biota) .The main source of SOM is litter (characterized by its amount and type). Both the sources and the decomposing factors depend, to a large extent, on climate and lithology. The sources and the decomposing factors of SOM vary in space and time, and on different scales, a regional scale, the macro conditions of climate control these variations, and on a local scale, the tempo-spatial differences within each region reflect the micro-environmental conditions that depend on the natural conditions (micro topography and surface cover components) and the type of land use. Land degradation is recognized as a main environmental problem that adversely depletes soil organic carbon (SOC), which in turn directly affects soils, their fertility, productivity and overall quality (FAO, 2017). The maintenance of SOC stocks in croplands and grasslands of the world is thus of upmost importance for ensuring global food security and the prevention of substantial CO_2 emissions.

SOM turnover plays a crucial role in soil ecosystem functioning and global warming .Soil organic matter (SOM) is all the organic material in the fraction <2 mm, which contains 40 to 60 % C, and which, depending on type of plant residues added to soils, composition and age, is often assumed to be, on average, 58 % C (Nelson and Sommers, 1982). Soils are one of the environmental components that plays the role of great storage for atmospheric carbon dioxide through the soil, vegetation, ocean and the atmosphere. The amount of SOC stored in a given soil is dependent on the equilibrium between the amount of C entering the soil and the amount of C leaving the soil as carbon-based respiration gases resulting from microbial mineralization and, to a lesser extent, leaching from the soil as dissolved organic carbon(DOC). Locally, C can also be lost or gained through soil erosion or deposition, leading to the redistribution of soil C at local, landscape and regional scales. Levels of SOC storage are therefore mainly controlled by managing the amount and type of organic residues that enter the soil (i.e. the input of organic C to the soil system) and minimizing the soil C losses (FAO and ITPS, 2015). Factors controlling the decomposition of organic matter in soil include soil temperature and water content (mainly determined by climatic conditions) which greatly influence soil C storage through their effect on microbial activity. The composition of the microbial community (e.g. the bacteria: fungi ratio) may also have an influence on the preferential decomposition of certain compounds (Marschner *et al*., 2008).

The rate of C storage in the soil can be expanded by the adoption of specific management practices (Smith *et al*., 2008; Lal *et al*., 2010). However, to suitably monitor these estimates in terms of magnitude, methodological standardization and periodic monitoring must be addressed in long-term studies. Recent investigations showed that methodological differences are a source of variability in estimates of soil C storage (Batlle-Bayer *et al*., 2010), particularly with regard to conversion of land use, which always brings about changes in bulk density (Ellert *et al*., 2002; Don *et al*., 2011). In addition, C accumulation is usually measured in terms of total C stored in the soil; however, the “potential storage amount” and “potential storage time” depend on the turnover (residence time) of the C reservoirs.

Some conceptual models have been developed in an attempt to account the stock of SOC and its components and to describe the formation and decomposition processes of organic matter (OM), which assumes that OM carbon (TOC) is stored in pools or compartments. Many models have been constructed in an attempt to describe the dynamics of soil organic-matter (SOM) turnover, which include: SOMM, ITE, Verberne, Roth-C …etc. . Roth-C model is the most wildly used and tested. It is a model for the turnover of organic carbon in non-waterlogged top soils that allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process. It uses a monthly time step to calculate total organic carbon (t ha $^{-1}$), microbial biomass carbon (t ha $^{-1}$) of the soil can be calculated) on a years to centuries timescale (Jenkinson *et al*., 1991 and 1992; Jenkinson and Coleman, 1994). The Century Ecosystems model (Parton *et al*., 1987; Smith *et al*., 1997) assumes that OM carbon (TOC) is stored in pools or components designated as: the “active” component, with a rapid turnover [one to five years], usually represented by microbial biomass (Jenkinson and Powlson, 1976) and soluble organic C in the soil (Paul, 1984; Kaiser and Guggenberger, 2000). The objectives of this study are: to show the effect of local factors including parent material, land use, climatic condition and soil type on the stock of soil organic carbon (SOC), and predict the total content of SOC and its compartments using the Roth – C Model.

Material and Methods

Description of the study area

Soils in Iraqi show a low content of organic matter (OM) , ranging from less than 1% in most soils of central and southern Iraq, to more than 5% in Northern Iraq. The decline of OM in soils reflects the effects of aridity, land degradation and biodiversity losses, whereas higher content indicates improvements in soil conditions due to higher rainfall, low temperate and dense vegetation cover. Five locations were selected to represent the status of organic matter content in soils of the dominant physiographic regions of Iraq including: Mountains, Foothills, Jezira, Lower Mesopotamian Plain, and Deserts (Figure 1). Two locations were selected in dry farming region, Northern -Iraq. The first location in Erbil governorate consists of two farms with native vegetation of grass and forest (Erb.1 and 2). While the second location in Sulamania Governorate represents cultivated farms (Sul 1and 2). Two other locations were selected in irrigated regions southern and western Iraq. The first location in Babel consists of two farms of bare and cultivated land (Bal 1 and 2). The second location in AlMuthana Governorate represents the desert land consists of two farms with bare and cropped land (Des. 1 and 2). The fifth location in Basra Governorate representing the dry Marshland area consisting of two farms with native Reed vegetation (Bas 1 and 2).

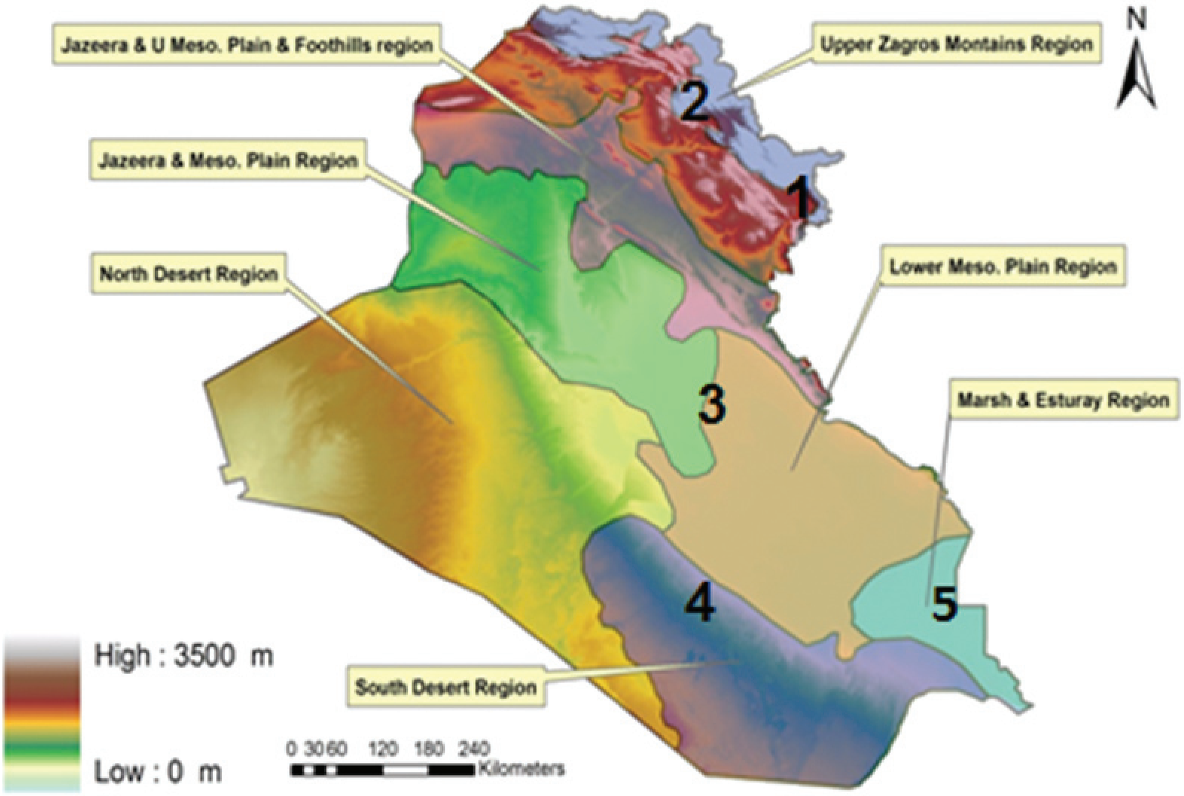

Figure 1. Location of the Selected Sites.

Each region has its specific geological (parent material), hydrological, ecological, climatological conditions, and soil conditions. The climate of Iraq is mainly of the continental, subtropical and semi-arid type, with the north and north eastern mountainous regions having a Mediterranean Climate. Rainfall occurs during the winter months, from December to February in most parts of the country and November to April in the mountains, with average day temperature of 16°C dropping at night to 2°C with a possibility of frost. Summers are dry and hot to extremely hot, with a shade temperature of over 43°C in July and August, yet dropping at night to 26°C. Rainfall is highly erratic in time, quantity and locations, and ranges from less than 100 mm in the south and southwest to about 1,000 mm/year in the north and northeast. Iraqi soils show different degrees of development representing by the presence of five soil orders as identified by Muhaimeed *et al*. (2014). The soils of the selected location according to this classification are: Aridisols , Entisols , Mollisols ,and Vertisols.

Land Use and Management

The main soil management systems in the selected farms represented by crop- fallow rotation including wheat- fallow, maize –fallow, Barley-fallow, as well as the native vegetation mainly tall grasses and forest in the mountain and marshland area. The predominant grass species are Panicum and Coloniao as well as the reed in the marshland area, and the dominant native forest was Deciduous Forest without human intervention. Soil Samples were taken from all the selected farms (0- 30 cm).The soil texture was analyzed by the pipette method (Day, 1965). Bulk density was determined by clod method covering with paraffin wax, as described by Black and hartge (1986).Total organic carbon (TOC) content was evaluated by the wet oxidation method, with external heating (Yeomans, and Beremner,1988). The total C stocks (TOC) were calculated for the 0.0 - 0.30m by the equation (1):

$$\textbf{Initial SOC Stock} = \textbf{SOC} \times \textbf{Bd} \times \textbf{Sd} \quad (1)$$

where: SOC – concentration of soil organic carbon (%) , Bd – bulk density (g/cm^3) , and Sd– topsoil depth (cm) (jurčová and Bielek,1997).

EC of the soil extract (1:1) was measured by an EC meter device (multiline P4/Set-2) according to (Rowel,1994). Plant residues and crop yield were measured for each site. The active OC compartments were calculated by using the Roth-C model. Climatic data for each site were collected from the nearest metrological stations for each of the selected locations.

Roth- C model:

Roth-C model is one of the most widely used models for the estimation and prediction of SOC stock on agricultural land, because of its simplicity and the generally good availability of the input data required, The Roth-C model splits SOC into four active components and a small amount of inert organic matter. The active components are the Decomposable Plant Material (DPM), Resistant Plant Material (RPM), Microbial Biomass (BIO) and Humified Organic Matter (HUM). Inert organic matter (IOM) content in Roth -C model is defined as a fraction of soil organic matter that is biologically inert and has an equivalent radiocarbon age of more than 50 000 years. The incoming plant carbon is split between DPM and RPM, depending on the DPM / RPM ratio of the particular incoming material. These pools in turn decompose exponentially to form CO_2 and BIO+HUM. The clay content of the soil (in percentage) is one of the input parameters and is used to calculate how the topsoil can hold the water available for plants and it also affects the way in which the organic matter decomposes. The clay content determines the ratio between the CO_2 and BIO+HUM produced. The decomposition rate is modified as a function of temperature, soil moisture deficit, and the presence of the plant cover (Coleman and Jenkinson, 2005).

Input data:

The Roth-C model requires three types of data:

- (a) Soil data – clay content (%), inert organic carbon (IOM), initial soil organic carbon (SOC) stock (t C/ha), depth of the soil layer considered (cm)(Table 1). Initial SOC stock (t C/ha) was calculated according to equation (1) from the available topsoil data coming from the Complex soil survey database.
- (b) Climatic data – monthly rainfall (mm), monthly evapotranspiration (mm), average monthly mean air temperature (°C) (Tables 2, 3 and 4) for the period 1990- 2010.
- (c) Land use and land management data - soil cover, monthly input of plant residues (t C/ha), monthly input of farmyard manure (FYM) (t C/ha), residue quality factor (DPM/RPM ratio). The management data were obtained on the basis of field observation and questionnaires which had been addressed to all users of the selected sites.

Results and Discussion

Soil Properties:

The results indicate that the soils of the selected farms show some variations in the content of clay, organic matter, and the Bulk density (Table 1). In general, the soils under dry farming system show higher clay content compared to other regions. Clay content ranged from 18.1% in the soil of babel in irrigated farm (Bab 2), to 55.9% in the soils of Erbil under dry farming system (Erb. 2). The high clay contents in some farms are due to the effect of parent material, topographic location and climatic conditions. Soils under dry farming system are formed from colluvium parent material rich in clay content. Erbil farms of the dry farm system are located in the lower depression that receive high mean annual rain fall with low mean annual air temperature and lower mean monthly evapotranspiration (1035.9mm, 17.65C° and 1882.1mm, respectively), when compared with the irrigated farms (Tables 2, 3, and 4), which allowed an- increase in the available moisture content and increased the rate of weathering, clay formation, and soil development (Jenny, 1994; Boul, *et al*., 2003). This was reflected by higher amount of plant residues added to the soils and an- increase in organic matter content in the Erbil farms compared to other locations mainly the desert farms. The desert farms showed the lowest amount of plant residues and organic matter content due to the dominant dry climatic conditions (low mean annual rain fall, high air temperature and high evapotranspiration). In general, the farms with native vegetation, mainly deciduous forest, showed higher organic matter compared to other farms in both dry farming and irrigated regions. The native vegetation of deciduous forest allowed an increase of plant residues production and thus, the SOM (Figure 2). The Low amount of plant residues and SOM in the farms Southern Iraq is due to the effect of the crop rotation has been exposed for long periods of drought without recovering its natural vegetation, that resulted in reduction land productive potential, increasing degradation and decreasing the amount of plant residues. The effect of different cultivation practices also resulted in topsoil disturbance soil disaggregation, and increased SOM decomposition which reduces the carbon content in cultivated land.

Table 1. Some soil properties and type of plant cover for the selected farm.

Farm No	Clay (%)	Soil Texture	OM (%)	ECe (dS/m)	Bd (g/cm³)	Plant .Resd (t/ha)	Slope (%)	Plant cover (t/ha)	Soil Moisture (%)	Ground Water level cm
Erb 1	41.7	C	5.11	0.36	1.44	5.5	2	N.grass	8.4	V.deep
Erb 2	55.9	C	13.44	0.16	1.35	7.4	6	forest	10.5	V.deep
Sul 1	48.5	Si.C	2.02	0.30	1.80	3.0	2	wheat	6.6	V.deep
Sul 2	52.3	Si.C	2.10	0.62	1.80	3.8	2	corn	7.4	V.deep
Bab1	40.7	Si.C	0.64	37.4	1.39	0.0	1	bare	6.6	150
Bab2	18.1	Si.L	1.30	3.56	1.21	5.96	1	corn	7.4	150
Bas 1	55.8	C	4.4	10.1	1.23	4.44	1	N.Reed	16.5	80
Bas 2	37.8	SI.C.L	6.5	51.1	1.13	5.16	1	N.Reed	18.2	80
Des 1	20.0	Loam	0.43	0.6	1.20	0.0	1	bare	1.8	V.deep
Des 2	35.0	CL	1.19	0.8	1.32	1.2	1	wheat	2.3	V.deep

Bd: Bulk density, OM: organic matter.

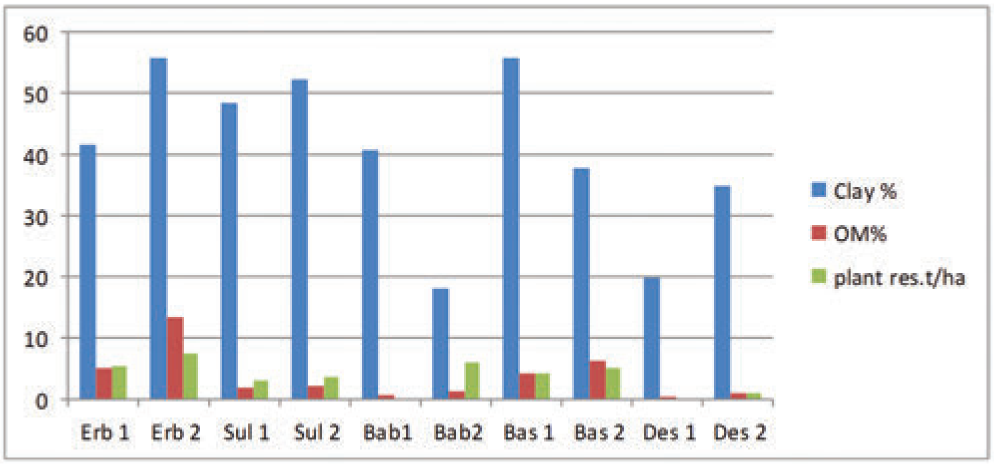

Figure 2. Percentage of clay, OM and the amount of plant residues in the selected farms.

Table 2. Total amount of rainfall (mm) for the selected sites.

Month	Erbil	Sulamania	Babel	Basra	Desert
Jan.	200.5	118.2	18.29	32	23.0
Feb.	121.5	115.1	12.00	17.8	16.7
Mar.	148.3	138.3	11.07	22.8	17.2
April	180.5	93.3	14.34	14.2	8.4
May	21.0	40.1	2.74	2.4	5.2
June	0.5	2.0	0.01	0	0
July	0.0	0.02	0.00	0	0
Aug.	0.0	0.01	0.00	0.3	0
Sep.	0.0	0.01	0.79	0	0.2
Oct.	33.8	23.8	2.88	6.3	5.2
Nov.	37.8	113.7	15.89	17.6	13.7
Dec.	292.0	112.0	18.88	25.6	16.0
Total (mm)	**1035.9**	**756.44**	**96.89**	**139**	**105.6**

Table 3. Mean monthly air temperature (oC) for the selected sites.

Month	Erbil	Sulamania	Babel	Basra	Desert
Jan.	4.1	7.1	10.65	12.3	11.7
Feb.	7.7	7.5	18.15	14.7	14.0
Mar.	12.1	10.1	18.21	19,5	22.0
April	13.6	17.4	24.65	26.2	24.8
May	21.0	23	30.79	32.4	30.7
June	27.9	28.1	35.00	36	34.6
July	31.7	38.1	36.79	37.8	36.2
Aug.	30.4	37.0	36.36	37.2	35.9
Sep.	22.9	28.2	32,18	33.7	32.5
Oct.	21.7	22.4	26.53	27.8	26.9
Nov.	13.7	13.1	25.48	19.8	19.1
Dec.	5.0	7.2	12.40	14	13.5
Mean(oC)	**17.65**	**19.93**	**25.6**	**25.95**	**25.2**

Table 4. Total annual Evapotranspiration (mm) for the selected sites.

Month	Erbil	Sulamania	Babel	Basra	Desert
Jan.	14.1	19.1	53.41	64.1	87.6
Feb.	37.1	20.0	112.10	85.4	118.6
Mar.	114.6	38.7	200.92	128.4	196.7
April	100.3	67.2	196.98	182.1	266.4
May	214.9	91.0	403.46	249.0	370.0
June	316.0	118.2	353.10	296.7	458.0
July	374.1	132.3	371.78	313.6	496.4
Aug.	312.8	130.0	340.34	307.5	466.0
Sep.	223.2	117.4	260.09	250.8	357.9
Oct.	111.5	84.6	245.82	172.3	253.1
Nov.	51.8	57.4	89.20	96.0	138.8
Dec.	12.3	37.2	60.25	65.2	87.3
Total (mm)	**1882.1**	**918.5**	**2687.45**	**2211.1**	**3296.4**

Organic Carbon Stocks and its Components:

The results from applying the Roth – C model to estimate the TOC stock and its components in the soils of the selected farms showed a wide variation among the farms selected for the study (Table 5 and Figure 3). The stocks of SOC are in a dynamic equilibrium between C inputs, mainly in form of crop residues and organic fertilizers, and a loss of C due to decomposition of soil organic. The decomposition of crop residue is controlled by both quantity and quality of the residue (Aerts, 1997, Jensen et al.,2005, Johnson, *et al*.,2007), climatic conditions such as temperature and moisture (Melillo,1989) and soil properties (Frouz, 2015). Low-quality plant residues with high carbon/nitrogen ratios, lignin, and other aromatic compounds decompose more slowly than high-quality plant litters (Wang, *et al*,. 2012). Soil water content is also an important factor that affects the decomposition of plant litter (Tulina, 2009). The total content of OC ranged from 8.25 ton.ha^{-1} in bare farm in the desert (des 1), to 316.47 ton.ha^{-1} in deciduous forest farm in Erbil governorate (Erb 2). These results are similar to the variations in OM content in the farms. The low content of TOC mainly in the desert farms is due to dry climatic conditions, soil texture and very low amount of biomass production and higher OC losses due to lower specific surface area, limiting the colloidal protection of the SOM (Silva and Mendonca, 2007). The higher TOC in the soil farms under the native vegetation, are probably related to the absence of soil disturbances and maintenance of plant residues on the soil surface, decreasing their decomposition and increasing the carbon in the Surface layer (Guareshi *et al*.,2013). Also, the results revealed that the methods of determination and correction of the carbon stock which is based on using bulk densty will affect the comparison of TOC stocks between different farms in the selected locations. The results indicated that the bulk density for the selected farms ranged from 1.13 gm.cm^{-3} in farm(Bas2), to 1.80 gm.cm^{-3} in farm (Sul1). In particular, the effect of the texture (~50 % clay) may have prevented the loss of organic C by the formation of stable complexes from humic substances and inorganic soil constituents (Oades, 1993; Stevenson, 1994; Zinn *et al*., 2005; Tristram and Six, 2007) .

Table 5. Stocks of SOC and its components calculated by Roth-C in the selected farms.

Farm .No	BIO t- C/ha	DPM t-C/ha	RPM t-C/ha	IOM t-C/ha	HUM t-C/ha	TOC t/ha
Erb 1	2.53	0.58	16.99	10.23	98.00	128.34
Erb 2	6.23	1.43	41.92	25.23	241.65	316.47
Sul 1	1.04	0.24	7.00	4.21	40.36	52.85
Sul 2	1.08	0.25	7.28	4.38	41.95	54.94
Bab 1	0.25	0.06	1.64	0.99	9.48	12.41
Bab 2	0.88	0.20	5.93	3.57	34.16	44.74
Bas 1	1.74	0.40	11.67	7.03	67.27	88.10
Bas 2	2.10	0.48	14.14	8.51	81.52	106.74
Des 1	0.16	0.04	1.09	0.66	6.30	8.25
Des 2	0.43	0.10	2.90	1.75	16.74	21.92

BIO: Microbil Biomass, DPM: Decomposed plant matterials, RPM: Resistant plant .materials, IOM: Inert organic materials, HUM: Humified organic materials

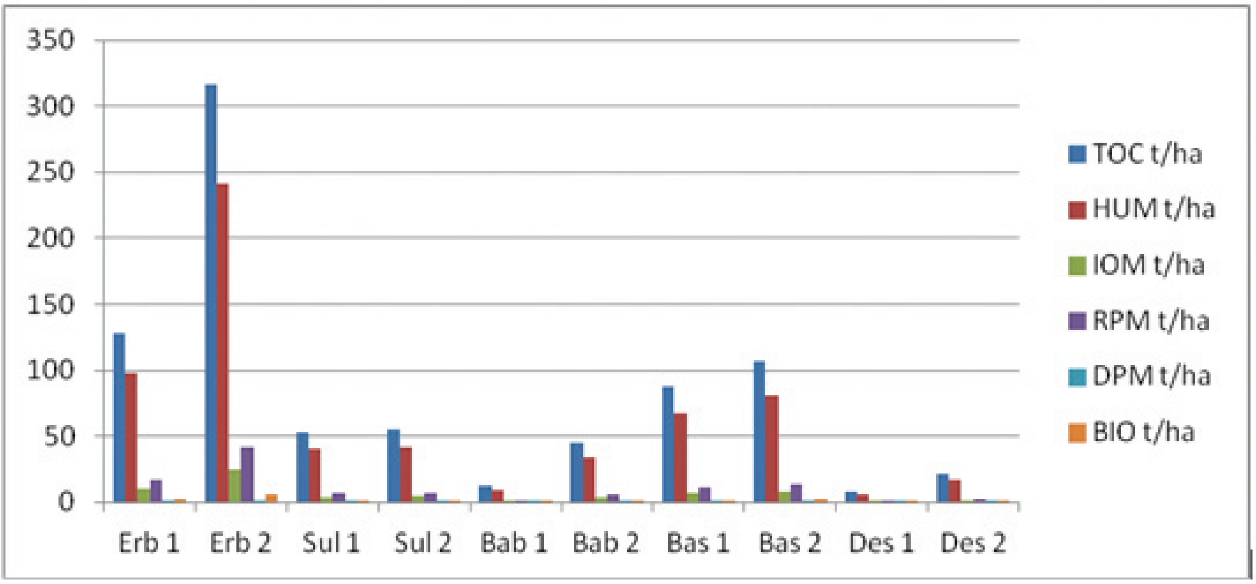

Figure 3. Amount of TOC and its components in the selected Farms (t. ha^{-1}).

In general, the results indicated that the SOC stocks bare farms is lower compared to the cultivated farms in all selected farms and locations due to the effect of cultivation which allow straw accumulation and the maintenance of soil moisture by irrigation under dry condition, which favored a continuous biological activity and plant residue decomposition, increasing the SOM contents (Loss *et al*., 2013).

The application of Roth- C model predicts that the SOC of the selected farms contains 0.45% C in RPM 2.0 % C in DPM, 7.97% C in POM, 13.24 % in BIO and 76.36% in HUM (Table 5). These results indicate that HUM is the most dominant compartment of the OC as it is the more stable partition of the SOM, which consists mainly of HUM, representing 76.36% of the total organic carbon (TOC). Humic substances are the most recalcitrant, stabilized and chemically reactive SOM fraction, which affect various properties that determine the quality of arid soils that are weathered and poor in available nutrients to plants (Silva and Mendonca, 2007).

Organic Carbon lost and CO_2 evolved:

The results (Table 6 and Figure 4) revealed that the percentage of OC lost and CO_2 evolved from the soils of the selected farms show similar pattern to the content of TOC. Soils of the native vegetation farms in northern and southern Iraq show the highest amount of OC lost and CO_2 evolved compared to the desert farms due to the high initial content of SOC in these soils compared to other farms. Soils of the native vegetation farms in Erbil location show the highest amount of OC lost and CO_2 evolved (2.421% and 1.834%, respectively), while soils of the desert bare farm show the lowest percentage of OC lost and CO_2 evolved (0.665 and 0.052 % respectively. These variations are due to the differences in rate of decomposition of plant residues (Nelson and Sommers, 1982; FAO, 2017) .

Table 6. Percentages of OC lost and CO_2 Evolved from the surface soils of the selected Farms.

Farm .No	OC lost (%)	Carbon dioxide Evolved (%)
Erb 1	0.983	0.748
Erb 2	2.421	1.834
Sul 1	0.410	0.311
Sul 2	0.426	0.323
Bab 1	0.100	0.076
Bab 2	0.221	0.174
Bas 1	0.710	0.537
Bas 2	0.860	0.656
Des 1	0.066	0.052
Des 2	0.176	0.135

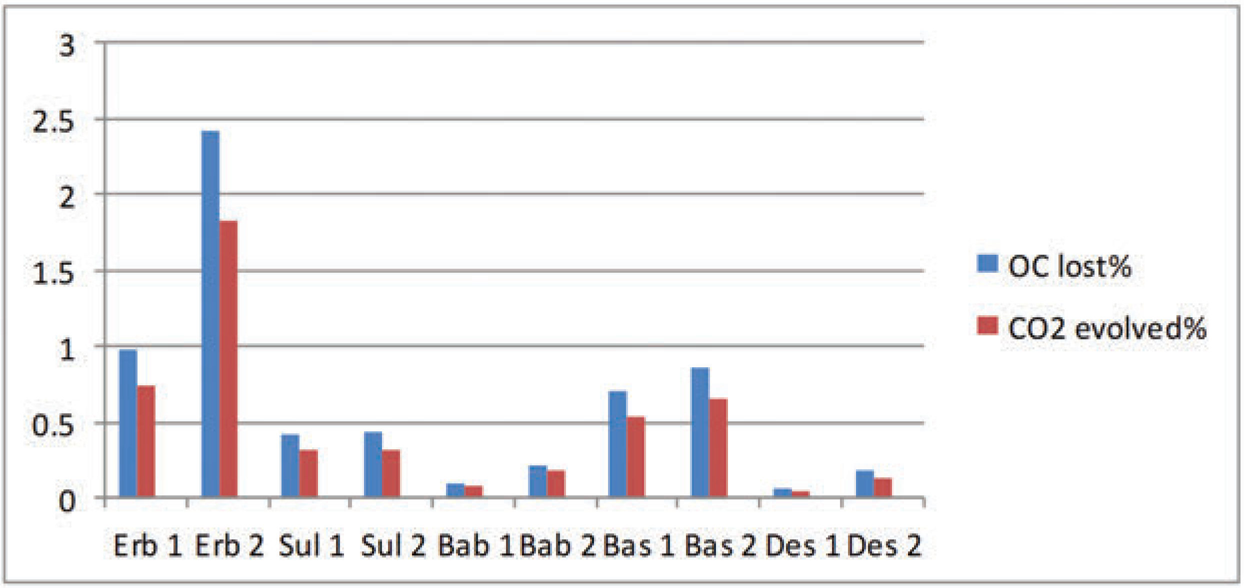

Figure 4. The percentage of OC lost and CO_2 (t.ha^{-1}) ebolved from the soils of the selected farms.

Conclusion:

The amounts of organic carbon and its active compartments vary from region to region and from farm to farm in the same region due to the variation in the decomposition rate of plant residues which is controlled by both quantity and quality of the residue, climatic conditions and soil properties. The soils of the selected farms show some variations in their properties attributed to the changes of organic carbon stocks and its compartments. Soils of the native vegetation (grasses and deciduous forest) show the highest content of the OC and its components. It can be concluded that Roth-C model is suitable for the estimation of SOC stock changes on Iraqi soils and can be used for the modelling of SOC stock changes.

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N° Ref: 919