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ASSESSMENT OF ORGANIC CARBON CONTENT IN DIFFERENT TOPOGRAPHIC FROM NORTHERN IRAQ USING REMOTE SENSING TECHNIQUE AND GIS

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Abstract

A study was conducted to seek the impact of landscape and surface parameter on the accumulation of organic carbon in soil. 20 samples were selected in Kurdistan region northern Iraq. Relationships between each of altitude, slope, and aspect with soil organic carbon was tested individually and together in linear and multiple regression models. Results showed that there was a positive relationship between altitude and aspects with soil organic carbon while it was negative with slope. Parameters all together explain more of the soil organic carbon content.
Keywords: SOC, soil organic carbon, slope, elevation, aspect, GIS, remote sensing

Introduction

Organic carbon in soil (organic carbon stock) is an important issue for soil health and fertility in the ecosystem (Feller *et al*., 2012, Abbott and Manning 2015). It is very important to study the organic carbon in soil because it plays an important role in changing the climate (Davidson and Janssens 2006, Tranvik and Jansson 2002). Organic carbon though is sensitive to soil management practices, where the bad land management practices would lessen the amount of organic carbon in soil releasing greenhouse gasses (Paustian *et al*., 1995, Smith and Conen 2004; Six *et al*., 2004) .Organic carbon in soil is susceptible to land use and soil management practices, and documenting organic carbon in soil is an important need revealed by mapping this feature to improve the evaluation methodology on national and international levels (Eswaran *et al*., 1993, Poeplau and Don 2013,Wesmeier *et al*., 2012).

Content of carbon in soil is considered as a major factor of general soil health where carbon works on improving soil physical and chemical properties such as cation exchange capacity, water retention in sandy soils besides enhancing soil aggregation in clayey soils (Doran and Parkin 1994, Lal 2016).

The decomposition of plants and animals are considered as the natural formation of organic carbon. In soils and sediments, a wide variety of organic carbon forms are present and range from freshly deposited litter (e.g., leaves, twigs, branches) to highly decomposed forms such as humus (Schumacker 2002).

Ritchie *et al*. (2007) have used topographic features to study soil organic carbon on the landscape, and they confirmed that topographic patterns have an impact on the redistribution of soil and organic carbon in the moving pathways of the landscape.

Hontoria and Rodriguez 1999 have studied the relationships between Soil organic carbon (SOC) and site characteristics in Peninsular Spain, and they used altitude and slope as of those factors affecting soil organic carbon besides climate, land use, and soil texture. They found that climatic variation that is affected by altitude and slope are good factors to control SOC.

Material and Methods

Area of Study

The area of study was representing the northern of Iraq namely Kurdistan area where 20 surface samples were randomly collected from Erbil, Suleimaniya, and Duhok. These samples were collected and GPS reading was recorded for each location. Figure (1) shows the distribution of soil samples locations.

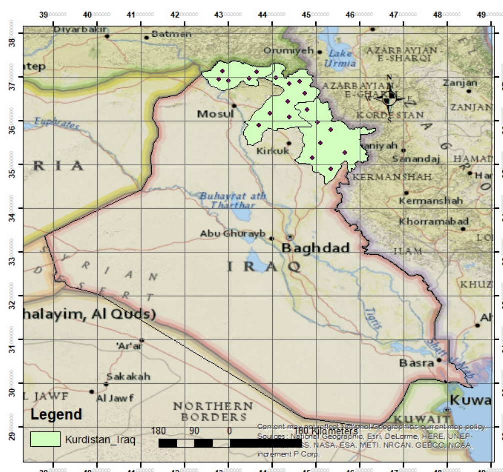

Fig. 1 : Study area and soil samples locations

Samples were collected in locked plastic bags and transferred for lab analysis.

Lab Measurements

Soil organic matter represents the remains of roots, plant material, and soil organisms in various stages of decomposition and synthesis, and is variable in composition. Though occurring in small amounts in soil, organic matter has a major influence on soil aggregation, nutrient reserve and its availability, moisture retention, and biological activity (Oades, 1995)

After collecting samples, they were saved in locked plastic bags and kept in a cold place (4 ^{o}C) for a holding time of less than 28 days to get prepared for analyzing organic carbon in them due to the method used to determine organic carbon that described in Jackson 1956.

Digital Elevation Model and remotely sensed Data:

A DEM of 25 m spatial resolution was used to extract elevation and slope of each point. Then relationship between organic carbon content, slope, and elevation was revealed using IBM SPSS Statistics V21.0.

Slope analysis

After using DEM information, mosaic satellite images of LandSat OLI sensor were used to contract slope analysis and extracting slope features using protocols suggested by Band 1986 and Jenson and Domingue 1988.

Altitude and slope values were extracted and relationship between them and organic carbon was calculated and plotted using SigmaPlot 11.0.

Results and Discussion

Altitude versus organic carbon content in soil

Figure (2) shows the altitude (Elevation) of the studied area where it generally ranged between 174-3583 m above sea level. Samples altitudes were ranging between 287- 1885 m above sea level where these points were reachable. The highest tips of mountains were very hard to be selected as site sample. The relationship between altitude and organic carbon was tested and table (1) shows the linear regression. Altitude has given a positive relationship with organic carbon content following the model: OC = 0.811 + (0.000419 * Elev) although, this relationship was week (R^2= 0.0523). the increase of organic carbon content with higher altitudes may be related to decreasing temperature and atmospheric pressure with higher altitudes the matter that lessen the decomposition of organic carbon in soil (Bird *et al.*, 1994; Sheikh *et al.*, 2009). But the week correlation could be related to that the higher altitude and mountainous areas has less vegetation cover that plain areas besides, it could be related to the effect of other factors in the content of organic carbon such as slope for instance (Gracia-Pausas *et al.*, 2007; Benites *et al.*, 2007).

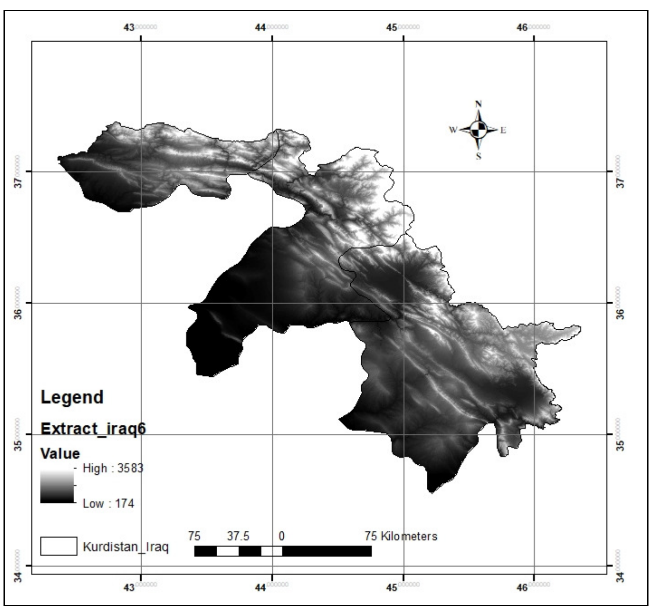

Fig. 2 : Digital elevation model (DEM) showing altitude of the area of study in meters

Table 1 : linear regression between elevati

Linear Regression				
OC = 0.811 + (0.000419 * Elev)				
N = 20				
R = 0.229Rsqr = 0.0523 AdjRsqr = 0.000				
Standard Error of Estimate = 0.769				
	Coefficient	**St. Error**	**t**	**P**
Constant	0.811	0.403	2.012	0.059
Elev	0.000419	0.000421	0.996	0.332

Analysis of Variance:					
	DF	**SS**	**MS**	**F**	**P**
Regression	1	0.587	0.587	0.993	0.332
Residual	18	10.650	0.592		
Total	19	11.237	0.591		

Slope versus soil organic carbon content

Figure (3) shows the impact of slope on the content of organic carbon in soil as slope were ranging from 0-73 degrees, while the selected sites slopes were ranging from 0.87-30.78 degrees.

The relationship between slope and organic carbon content in soil was tested and table (2) shows the linear regression between them. Slope also has given a negative relationship with organic carbon content following the model: OC = 1.338 - (0.0158 * slope) with week regression (R2=0.0394). This relationship describes that organic carbon content in soil decreases with the increase of slope values (Hao *et al.*, 2002; Wei *et al.*, 2010).

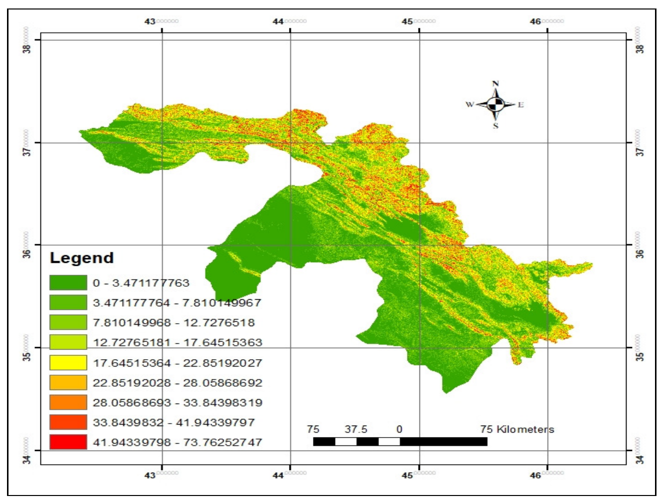

Fig. 3 : Slopes of the area of study

Table 2 : Linear regression between slope and soil organic carbon content

Linear Regression				
OC = 1.338 - (0.0158 * slope)				
N = 20				
R = 0.199 Rsqr = 0.0394 AdjRsqr = 0.000				
Standard Error of Estimate = 0.774				
	Coefficient	**St. Error**	**t**	**P**
Constant	1.338	0.257	5.214	<0.001
Slope	-0.0158	0.0184	-0.860	0.401

Analysis of Variance:					
	DF	**SS**	**MS**	**F**	**P**
Regression	1	0.443	0.443	0.739	0.401
Residual	18	10.794	0.600		
Total	19	11.237	0.591		

Aspect versus organic carbon in soil

Aspect was tested as a factor affecting the content of organic carbon in mountainous soils of Kurdistan region in Iraq. Figure (4) shows the aspect classes found in the area of study.

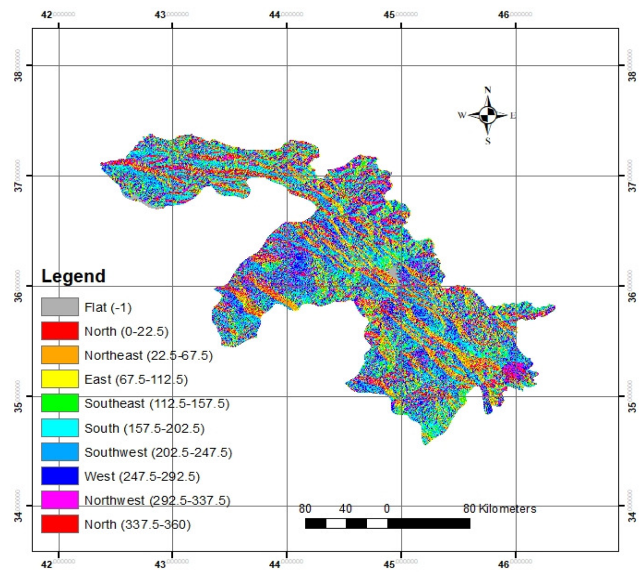

Fig. 4 : Aspects of the area of study

These aspects are majorly in ten categories starting with flat area followed by all possible direction of facing sun rays of the land cover which is assumed soil in this trait as north, northeast, east, southeast, south, southwest, west, northwest ranging from -1 to 360 degrees.

The relationship between aspect and organic carbon content in soil was tested and it was found that organic carbon increases with increasing the aspects towards the north direction as: OC = 1.145 + (0.000154 *aspect) but with a low regression (R2=0.000239). This increase could be related to that north and northwest directions are colder than other directions therefore there should be a possible increase in soil organic carbon. Table (3) shows the linear regression of organic carbon content in soil with aspect.

Table 3 : Linear regression between aspect and soil organic carbon content

Linear Regression					
OC = 1.145 + (0.000154 * aspect)					
N = 20					
R = 0.0155 Rsqr = 0.000239 AdjRsqr = 0.000					
Standard Error of Estimate = 0.790					
	Coefficient	**St. Error**	**t**	**P**	
Constant	1.145	0.487	2.349	0.030	
Aspect	0.000154	0.00234	0.0656	0.948	
Analysis of Variance:					
	DF	**SS**	**MS**	**F**	**P**
Regression	1	0.00269	0.00269	0.00431	0.948
Residual	18	11.235	0.624		
Total	19	11.237	0.591		

Altitude, Slope and Aspect versus organic carbon in soil

In landscapes, elevation, slope and aspectare considered the major component that feature it (Gessler *et al*., 1995; Dymond *et al*., 1995) therefore, these components were studied separately in linear regression (as mentioned above) and together as multiple regression, and table (4) shows the multiple regression of altitude, slope, aspect and organic carbon content in soil. Multiple regression has showed a high relationship between landscape parameters (altitude, slope, and aspect) and organic carbon content in soil following the model: OC = -0.913 - (0.120 * slope) + (0.00309 * Elev) + (0.00333 * aspects) with a relatively high regression coefficient (R^2= 0.692) which means that the organic carbon in soil is highly affected by altitude, slope and direction of facing sun lights (aspect).

Table 4 : Multiple regression between (altitude, slope, and aspect) and soil organic carbon content

Multiple Linear Regression					
OC = -0.913 - (0.120 *slope) + (0.00309 *Elev) + (0.00333 *aspects)					
N = 20					
R = 0.832Rsqr = 0.692 AdjRsqr = 0.634					
Standard Error of Estimate = 0.465					
	Coefficient	**Std. Error**	**t**	**P**	**VIF**
Constant	-0.913			-1.663	0.116
Slope	-0.120			-5.658	<0.001
Elev					
Aspects					
Analysis of Variance:					
	DF	**SS**	**MS**	**F**	**P**
Regression	3	7.776	2.592	11.979	<0.001
Residual	16	3.462	0.216		
Total	19	11.237	0.591		
The dependent variable OC can be predicted from a linear combination of the independent variables:					
P					
Slope <0.001					
Elev <0.001					
Aspects 0.057					

Figure (5) shows that there was higher content of soil organic carbon with higher elevation and lower slopes where the higher values of organic carbon are found on the left corner of the figure where higher altitude and lower slopes.

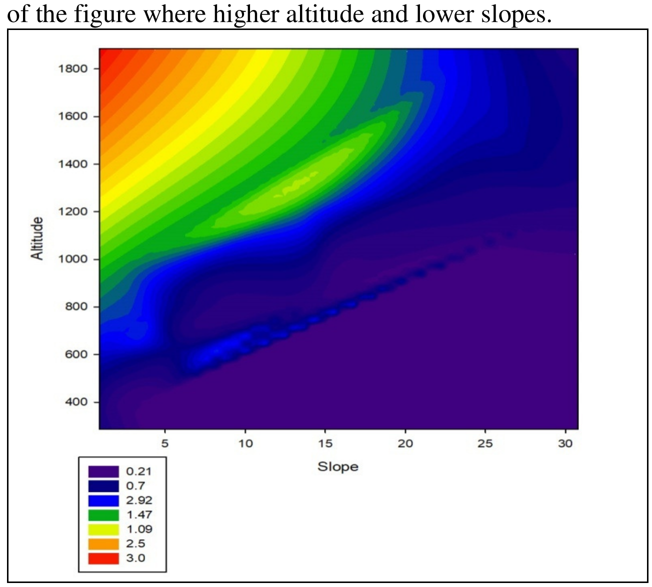

Fig. 5 : Effect of altitude and slope on organic carbon content in soil

Conclusions

It was obviously found that individual surface parameter cannot explain the relationship of the feature with the content of organic carbon in soil, while multiple parameters can explain the relationship between surface and organic carbon in soil. Therefore, the more parameters tested the higher correlation explaining this relationship. Although, altitude increase would definitely increase carbon content in soil while increasing slope leads to a decrease in soil organic carbon. Also facing north and northwest aspects gives higher content of carbon.

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