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ORIGINAL ARTICLE

Evaluation of Distribution Functions of Organic Carbon with Soil Depth in Vertisols and Inceptisols

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ABSTRACT
The soil organic Carbon is the important and active factor in the global Carbon cycle and it has significant interaction with other elements in the nature. The soil organic Carbon undoubtedly has an irreplaceable role in maintaining and quality improvement of ecosystem for all creatures including human. The amount of organic Carbon in the different soils has had significant differences with each other and any type of soils can store different amounts of Carbon. The above study evaluates the functions of organic Carbon distribution with depth in Vertisols (Sartipabad) and Inceptisols (Tavalloli) series in south of Bilevar area north of Kermanshah province with 16 profiles in Vertisols and 2 profiles in Inceptisols using SMADA software. The results showed that the amount of organic Carbon reduction with depth in Vertisols is slower due to pedoturbation processes. Strong Clay-humus complexes, high clay percent and abundant fine Aggregate subsoils in Vertisols can store more organic Carbon than Inceptisols. Distribution of organic Carbon with depth in the sample profiles of both soils followed logarithmic functions and correlation coefficient was -0.99 and -0.97 respectively.
Key words: *Inceptisols, Kermanshah province, Pedoturbation, Vertisols, Soil organic Carbon*

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INTRODUCTION

The soil organic Carbon is the most important in the fertility, soil quality and ecosystem protection particularly in semi-arid areas. The management of this major property of soil needs to place processing, structure recognition and its variability factors in place and time. The evaluation of amounts of soil organic Carbon and its changes presents the management effects on the soil health [1].

In our country except a limited arena, the soil organic Carbon is very low in the more production fields as cultivation, pasture and even more forest areas. The researchers are believed that the slight change on the amount of organic Carbon can have high effect on the soil functions and finally its quality in semi-arid and arid condition of country [2].

The soil organic materials form the major segment in the Carbon global cycle and it is as the largest source of carbon store. Available carbon in the soil organic materials has been allocated 80% of Terrestrial Carbon to its and so it consider as the important source of carbon store for greenhouse gases reduction. Accordingly, the soil organic materials play the important role in regulating the atmosphere combination particularly with CO_2 [3].

The soil organic materials play the major role in the subsoils protection and stability particularly in Vertisols, Alfisols, Inceptisols and Ultisols [4].

The amount of organic materials in the soil in a defined point is the result of complex interactions of the parent materials, climate, topography and… in during time [5]. In the different landscapes in the regional scales be control the content of organic materials by the sediment, temperature, soil texture and type of crop cover [6].

The soil ability in its life giving functions such as providing nutrient elements for plants, the distribution and store of water, the greenhouse gases reduction, pollutants purification, resistance against destruction and crop production in framework of a stable management is extremely affected the organic material [7].

The organic materials are the important index for the soil fertility that it is the interaction result of physical, chemical and biological processes of soil. The organic materials with condition improvement of making subsoil, improve porosity and permeability status of soil [8]. Among of soil inherent properties, the soil texture has the most effect on the soil organic Carbon and providing to correspond of environment conditions, the soil with fine texture save the more organic Carbon [9].
In Iran with semi-arid and arid climates, not only the soils has been the poor of the organic materials (lower of 1%) but fixing and protection of amount of soil organic Carbon is very difficult.
The aim of doing this study is the evaluation of organic Carbon distribution in Vertisols of studied area compared with Inceptisols.

MATERIALS AND METHODS

The area under investigation is located in the Geographical bounded 34.30° - 34.45° latitude and 46.45° - 41.00° longitude 30 kilometers of the North of Kermanshah province in the South of Bilehvar plain in Iran (Figure 1). The vital climate is meditranean area, the long average of its falling 310 millimeters, its height amplitude 1345-1600 meters from sea level. This region has warm summer and nearly cold winter and is a depositing riverside plain. The whole area is 1850 hectares and includes 4.6 percent of the whole Bilehvar plain lands [10]. The maternity materials that form this region soil are from tiny structures of linear deposits and lime stone [11].

Figure 1. Location of the studied area

At first the region geo forms were separated in different levels by interpreting aerial pictures and with the help of topographic maps and geology on the basis of 1:50000 standard.
After defining the sample places for semi–general study of the region on the basis of 1:20000 standard, profile was drilled in defined places and a sample with the weight of 2 Kg was harvested from the horizons of each profile. After describing the profiles in defined places and sampling, the untouched samples were carried to the lab for physical and chemical analysis. In all places of sampling, the height information from sea level, the amount and the direction of the slope and the geographical features were written down.
The characteristics of soil including the soil Texture [12], Bulk density (Bd) [13], Soil organic carbon (OC) [14], Soil reaction (pH) [15] and electrical conductivity (EC) were measured on 1:1 extract (Soil: Water) [16] were identified.
The analysis done by SMADA software.

RESULTS AND DISCUSSION

Average of organic Carbon amount in the different depths of Vertisols profiles (16 profiles) showed in table 1 and the average of organic Carbon amount in the different depths of Inceptisols profiles (2 profiles) in table 2.
Correlation functions of organic Carbon with depth in Vertisols showed in table 3. Relation of organic Carbon with depth in different depths on 13 studied profiles with 8 depths (81.25%), logarithmic function is maximum of correlation coefficient (Figure 2) and in 2 studied profiles with 8 depths (12.5%), the exponential function is maximum correlation coefficient (Figure 3) and so in 1 studied profile with 8 depths (6.25%), liner function is maximum correlation coefficient (Figure 4).

Correlation functions of organic Carbon with depth in Inceptisols profiles of studied area showed (Table 4) that in every 8 depths of studied profiles, the logarithmic function is maximum correlation coefficient (Figure 5).

Table 1. The average of organic Carbon amount in the different depths of profiles in Vertisols order (Sartipabad series)

Organic Carbon (%) Depth (cm)	Profile															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0 – 15	1.53	3.02	3.54	3	2.98	1.72	3.51	1.55	1.6	1.74	1.59	1.44	1.2	1.53	1.55	1.29
15 – 30	1.17	2.64	1.82	2.08	2.78	1.68	2.46	1.13	1.55	1.53	1.18	1.48	1.39	1.39	1.4	1.18
30 – 45	0.85	1.12	1.16	1.33	1.29	1.62	1.26	1.09	0.86	1.28	0.92	1.27	0.96	0.69	1.4	1.09
45 – 60	0.65	0.83	0.54	0.64	1.09	1.61	1.04	0.67	0.65	1.07	0.84	0.95	0.65	0.53	0.82	1.02
60 – 75	0.6	0.3	0.44	0.47	0.96	1.4	0.69	0.57	0.6	0.6	0.7	0.81	0.6	0.44	0.61	0.84
75 – 90	0.44	0.47	0.37	0.44	0.61	0.84	0.57	0.53	0.44	0.81	0.7	0.84	0.44	0.3	0.7	0.54
90 – 105	0.53	0.54	0.32	0.44	0.57	0.64	0.57	0.3	0.53	0.7	0.54	0.57	0.53	0.3	0.53	0.47
105 – 120	0.78	0.47	0.33	0.22	0.44	0.3	0.22	0.3	0.61	0.3	0.47	0.4	0.22	0.31	0.41	0.3

Table 2. The average of organic Carbon amount in the different depths of profiles in Inceptisols order (Tavalloli series)

Depth (cm) / Profile	Organic Carbon (%)							
	0 – 15	15 – 30	30 – 45	45 – 60	60 – 75	75 – 90	90 – 105	105 – 120
1	1.44	1.2	0.81	0.7	0.81	0.54	0.3	0.22
2	1.1	0.81	0.63	0.61	0.63	0.5	0.44	0.1

Table 3. Relation of organic Carbon with depth in Vertisols in the studied area (Sartipabad series)

Profile	Equation	R^2	SS_e	MS_e
1	$Y = 3.13 - 0.94 \ln(X)$	0.88	0.117	0.164
2	$Y = 5.6 - 1.24 \ln(X)$	0.88	0.923	1.382
3	$Y = 8 - 2.6 \ln(X)$	0.97	0.323	1.787
4	$Y = 5.6 - 1.35 \ln(X)$	0.97	0.228	1.329
5	$Y = 2.2 e^{(-0.014)X}$	0.93	0.158	0.343
6	$Y = -1 + 2.1 \ln(X)$	0.79	0.457	0.335
7	$Y = 6.7 - 1.7 \ln(X)$	0.97	0.274	1.726
8	$Y = 1.7 e^{(-0.016)X}$	0.97	0.041	0.227
9	$Y = 3.6 - 0.428 \ln(X)$	0.83	0.256	0.245
10	$Y = 0.059 + 1.15 \ln(X)$	0.97	0.034	0.213
11	$Y = 2.3 - 0.315 \ln(X)$	0.99	0.008	0.187
12	$Y = 4.8 - 0.73 \ln(X)$	0.93	0.454	1.246
13	$Y = 0.249 + 0.87 \ln(X)$	0.86	0.153	0.19
14	$Y = 2.4 - 0.334 \ln(X)$	0.89	0.181	0.31
15	$Y = 0.7 + 0.8 \ln(X)$	0.92	0.116	0.262
16	$Y = 1.4 - 0.00929 X$	0.88	0.115	0.136

Table 4. Relation of organic Carbon with depth in Inceptisols in the studied area (Tavalloli series)

Profile	Equation	R^2	SS_e	MS_e
1	$Y = 1.2 + 0.317 \ln(X)$	0.94	0.071	0.229
2	$Y = 1.46 - 0.152 \ln(X)$	0.95	0.022	0.079

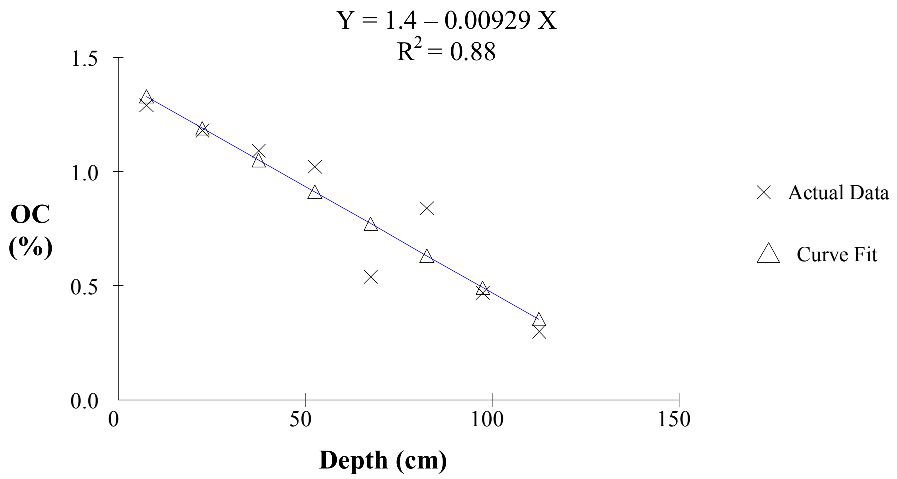

Figure 2. Process of organic Carbon changes with depth (logarithmic function) in Vertisols (Sartipabad series).

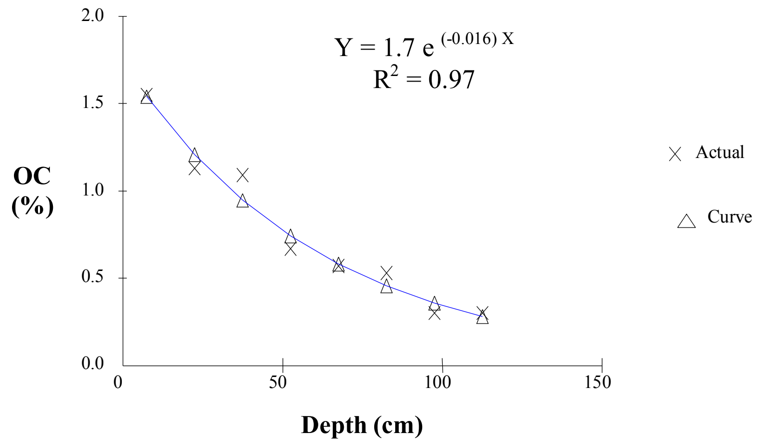

Figure 3. Process of organic Carbon changes with depth (exponential function) in Vertisols (Sartipabad series).

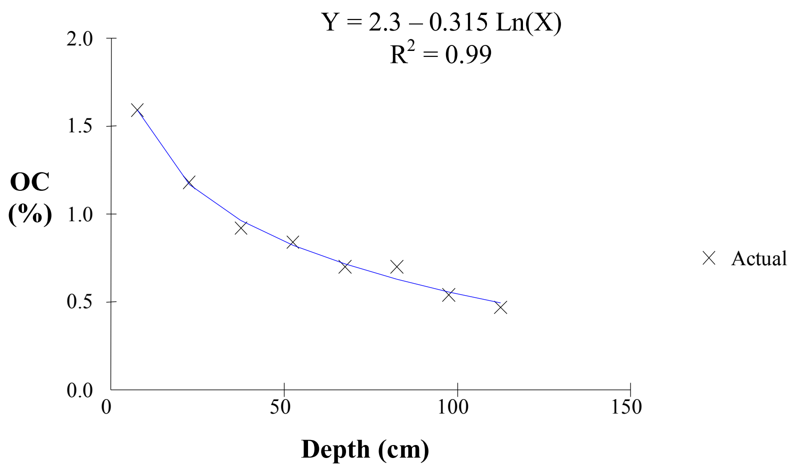

Figure 4. Process of organic Carbon changes with depth (liner function) in Vertisols (Sartipabad series)

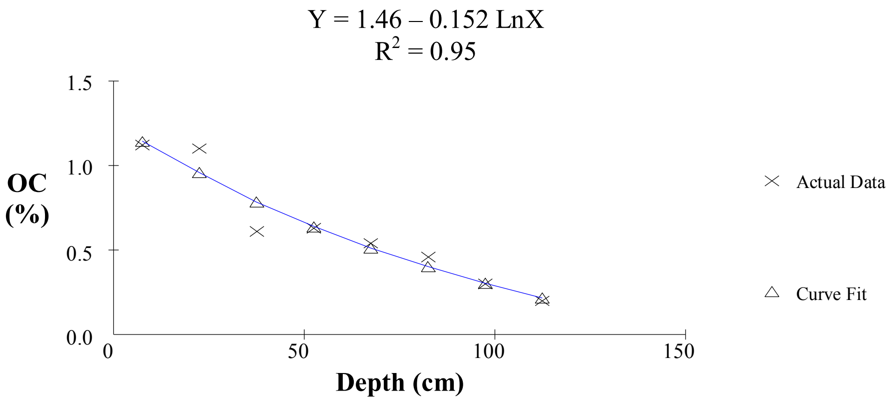

Figure 5. Process of organic Carbon changes with depth (logarithmic function) in sample profile of Inceptisols (Tavalloli series).

Table 5. Sample profile of Vertisols (Sartipabad series)

Very fine, Mixed, Thermic, Typic Haploxererts		
Horizon	Depth (cm)	Description
Ap	0 – 25	Dark brown (10YR3/3) Clay, strong Cloddy Structure, hard, semi-deformable, many prominent, dark brown 10YR3/3 (moist), slickenslides, common very fine roots, slightly alkaline, clear wavy boundary, (OC%= 1.4)
Bss	25 – 60	Very dark grayish (10YR3/2) Clay, Strong wedge Structure, semi-deformable, many prominent, very dark grayish 10YR3/2 (moist), slickenslides, few fine roots, neutral, clear wavy boundary, (OC%= 1.13)
$Bkss_1$	60 – 100	Brown (10YR4/3) Clay, Strong wedge Structure, slightly plastic, many prominent, brown 10YR4/3 (moist), slickenslides, few medium roots, slightly alkaline, clear smooth boundary, (OC%= 0.9)
$Bkss_2$	100 – 130	Light yellowish brown (10YR6/4) Clay, moderate medium angular blocky Structure, slightly plastic, many distinct, light yellowish brown 10YR6/4 (moist), slickenslides, few medium roots, slightly alkaline, (OC%= 0.81)

Table 6. Sample profile of Inceptisols (Tavalloli series)

Fine, Mixed, Thermic, Vertic Haploxerepts		
Horizon	Depth (cm)	Description
Ap	0 – 30	Dark grayish brown (10YR4/2) silty Clay loam, moderate medium angular blocky Structure, semi-deformable, common very fine roots, slightly alkaline, clear smooth boundary, (OC%= 1.11)
Bw_1	30 – 70	Grayish brown (10YR5/2) Clay loam, moderate fine angular blocky Structure, slightly plastic, few fine roots, slightly alkaline, clear smooth boundary, (OC%= 0.59)
Bw_2	70 – 100	Yellowish brown (10YR5/4) Clay loam, moderate fine angular blocky Structure, slightly plastic, few fine roots, slightly alkaline, clear smooth boundary, (OC%= 0.58)
Bw_3	100 – 130	Dark yellowish brown (10YR4/4) Clay loam, moderate fine angular blocky Structure, slightly plastic, few fine roots, moderately alkaline, (OC%= 0.54)

Table 7. The simple of process of Clay percent changes with depth in two orders of Vertisols and Inceptisols

Depth (cm)	Clay (%)	
	Vertisol	Inceptisol
0 – 15	51	33.8
15 – 30	53.8	34
30 – 45	53	34.3
45 – 60	53.8	26.2
60 – 75	56.8	26
75 – 90	59	26.4
90 – 105	61.4	30.2
105 – 120	62	32.4

The sample profile in Vertisols of area in table 5 and the sample profile in Inceptisols of area in table 6 have been described. Both of soils are under cultivation and in alternation of wheat and maize.

As that the sample profiles presented in figure 5, the amount of organic material reduction in Vertisols compared with sample profile of Inceptisols (Table 6) has been the gradual and correspond with the studies of Coulomble et al, [17]. And so likely this reduction process is caused the organic materials maintenance of result of pedoturbation in heavy texture of Clay this soils (Table 7), (Soils of fine texture play the important role in store of soil organic Carbon) that by the studies Boye *et al*. [9] and Shahoei [18] is the fit and suitable process of making subsoil and formation of fine subsoils that it confined about 60% of total organic Carbon and prevent with its protect of decomposing in Vertisols the process of organic Carbon reduction make slower than other orders of soil [19].

Lower horizons of Vertisols are darker even with amount of low organic Carbon than Inceptisols and other area orders that this is caused extremely complex of organic material-Clay in the horizons. Dark index this soils (value) according to Munsell booklet (Soil color charts) was 3 and lower of 3 that with it correspond with the studies Mermut *et al*. [20].

Amount of Clay and Silt high, increase water maintenance capacity and nutrient elements and finally production of biomass and reduces the Oxygen flow for decomposition. The soils with coarse texture provides very low surfaces to link with the organic materials that cause the lower biomass production and loss of high percent of soil organic materials caused the breathing annually.

The result of Rise et al study [21], showed that spread of the amount of particles in the Vertisols having sever Pedoturbation in the whole soil solum is monotonous. Considering the method of monotonous spread of the particles in present study one can point to the phenomena of active Pedoturbation in the Vertisols of the under study region, this phenomena causes server mixing of organic materials in soil and decreases the amount of decreasing organic Carbon of the soil in Vertisols of this region.

The present study is in accordance with Lorenz *et al.* [22] finding. They expressed that the amount of organic Carbon of under land horizons are usually much less than shallow soils. Whereas the big part of organic remains has been mixed inside the shallow soil or has accumulated on it, the organic material concentrates on upper layers. Depth of the soil can receive organic materials as organic Carbon solution. Measuring the organic Carbon in different depth of profile show that decreasing the amount of organic Carbon is along with increasing depth in such a manner that shallow horizon dissolves, where the plant remains have been added to it has the most amount of organic Carbon and its amount decreases when the depth increases.

Correlation of organic material with depth in Vertisols and Inceptisols of the studied area has been significant and followed the logarithmical function and so its correlation coefficients respectively was (-0.99 & -0.97) higher of other functions.

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