Carbon sequestration under different physiographic and climatic conditions in north Karaj river basin

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Abstract

Some of the most important local factors on soil carbon sequestration are climatic conditions (such as precipitation, temperature and sun radiation) and physiographic properties (such as elevation, slope shape, slope degree and slope aspect). We investigated the effects of climate and physiographic properties on soil carbon distribution and sequestration. Four elevation and five precipitation classes were considered, by compilation of a topographic map (1:50000) and DEM of the studied region. The results show that except for the lowest elevation class organic carbon contents decrease with increasing elevation. In other words the maximum organic carbon content belongs to elevation class no. 2 (2250- 2500 m), which corresponds to precipitation class no. 3. The highest carbon content was observed in middle precipitation class and elevation class no. 2 which is significantly far from grazing and human activities and also receives more suitable climatic conditions (precipitation and temperature) without a vegetation period limitation. The results indicate that the physiographic and climatic conditions play important roles in land management in order to achieve soil carbon sequestration. Considering the physiographic and climatic conditions different management schedules including replanting species, grazing and soil protection should be considered.

Key Word

Physiography, climate, carbon sequestration, organic carbon

Introduction

Physiographic properties (such as elevation, slope shape, slope degree and aspect) and climatic conditions (such as precipitation, temperature and radiation) are among the most important factors affecting soil carbon sequestration for each region. In this study we have investigated the effects of climatic and physiographic properties on soil carbon distribution and sequestration at the northern region of Karaj, Iran. Effects of climate change on soil organic carbon storage and its distribution differ between different regions, and temperature and rainfall levels are among the main influencing factors causing the differences. Temperature and humidity are important factors affecting the rate of organic material decomposition. Decomposition doubles with every 10 °C increase in temperature, while the increase in soil moisture increases the amount of organic matter. Landscape attributes including slope, aspect, elevation, and landuse are the dominant factors influencing SOC in areas with the same parent material and climate regime. Landscape attributes affect organic activities, run-off and run-on processes, condition of natural drainage, and exposure of soil to wind and precipitation (Dianwei *et al.* 2006). Comparison between SOC contents of different slope shapes showed that concave slopes have higher SOC and less soil loss than convex slopes. These patterns are the same as have been shown in other studies. The slope gradients were less for the concave slopes indicating a convergence and potential slowing of run off which would allow water to slow and eroded soil particles to be deposited thus SOC decreases as slope gradient increases (Jerry *et al.* 2007).

Methods

Four elevation classes (class1=2000-2250 m, class2=2250-2500 m, class3=2500-2750 m, class4=2750-3000 m) and 5 precipitation classes (class1=350-400 mm, class2=400-450 mm, class3=450-500 mm, class4=500-550 mm, class5=550-600 mm) were defined. ETM^+ satellite images of 2002 were analyzed and classified, using PCA software. A digital elevation model (DEM) of the studied region was obtained from the topographic map (1:50000 scale) in Arc-GIS environment, and different physiographic characteristics including (slope, altitude, aspect) were extracted. Landform units were determined by intersecting the slope, hypsometric and aspect maps. Climatic information also was obtained from the regression models, which exist between precipitation and temperature with elevation (eqs. no. 1 and 2) respectively at the studied region.

$$P(mm) = (0.2055 \times elevation) - 30.039 \quad (1)$$

$$T(°C) =(-0.0073 \times elevation) + 24.435 \quad (2)$$

Physicochemical characteristics of 24 surface samples (Table 1) were analyzed. Sampling design carried out according to joint sampling from opposing aspects at different altitudes and climatic conditions (precipitation and temperature). Figure 1 shows the schematic position of the studied area.

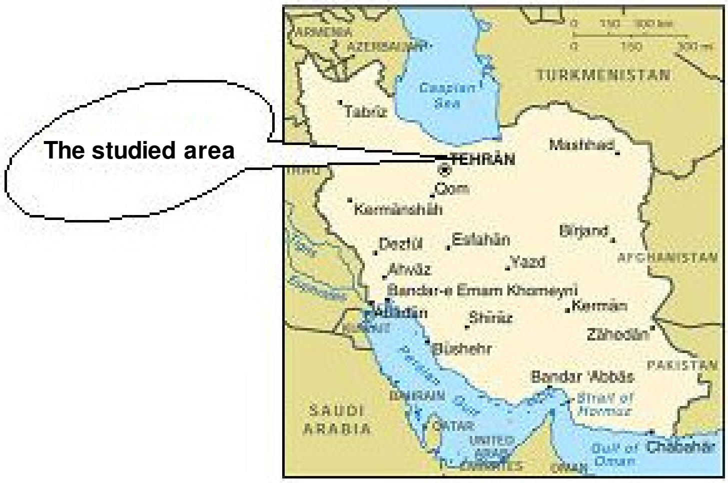

Figure 1. Schematic location of the studied area.

Results

The results showed that the two lowest organic carbon contents belong to the lowest and highest elevation classes (Figure 2b), although not for the same reasons. In the case of the lowest elevation class, due to lower precipitation, its accessibility for intensive grazing, and soil and vegetation disturbances, organic carbon content is low. While in the case of the highest elevation class, low organic carbon content is the result of shorter vegetation period due to the colder temperature regime, which restricts organic matter input. The highest OC content was observed in the elevation class no. 2 (2250-2500 m) and class no. 3 and 4 were the next steps accordingly. The middle elevation and precipitation class temperature regimes have rather suitable conditions due to longer vegetation periods. Also with increasing the elevation till 3000 m precipitation increases, but decreasing temperature below the biological zero point restricts the yield of vegetation cover and thus the soil organic carbon content.

Table 1. Selected chemical and physical properties of samples.

No	EC	pH	%Clay	%Silt	%Sand	CEC	%$CaCO_3$	OM	%N	C/N
1	2.52	7.77	19.6	46	34	12.8	5.58	0.85	0.066	7.5
2	1.00	8.13	9.6	28	62	1.0	2.12	0.85	0.074	6.6
3	1.23	8.09	6.3	34	60	11.2	2.08	1.35	0.068	11.5
4	1.35	7.95	8.3	30	62	17.0	3.56	0.81	0.085	5.5
5	0.72	8.09	17.6	18	64	4.1	2.77	0.89	0.077	6.7
6	0.92	7.57	8.3	26	66	6.7	2.85	2.62	0.162	9.4
7	2.35	8.03	10.3	28	62	2.0	0.65	2.55	0.173	8.5
8	1.73	8.19	22.8	15	62	5.1	2.33	1.04	0.093	6.5
9	2.64	7.97	11.7	24	64	16.1	1.94	0.04	0.121	0.19
10	1.16	7.89	9.6	32	58	2.4	1.90	4.09	0.264	9.0
11	1.16	8.05	12.3	24	64	4.2	0.98	0.81	0.062	7.6
12	2.58	7.96	19.6	34	46	14.7	1.94	0.93	0.116	4.6
13	2.37	8.31	9.7	38	52	16.3	1.97	2.47	0.156	9.2
14	1.30	7.99	9.7	32	58	17.2	2.91	1.42	0.118	7.0
15	0.74	7.95	7.6	16	76	12.7	3.38	2.59	0.223	6.7
16	2.21	8.11	7.6	16	76	9.3	0.00	1.58	0.127	7.2
17	1.12	8.04	15.7	40	44	10.5	1.03	0.19	0.110	1.0
18	0.69	8.01	13.6	24	62	15.2	2.62	0.93	0.132	4.1
19	2.72	7.98	17.7	32	50	15.2	1.12	1.12	0.163	4.0
20	1.26	7.39	15.6	46	38	18.7	1.27	7.72	0.493	9.1
21	1.01	7.43	4.3	19	77	10.7	3.13	4.09	0.180	13.2
22	1.53	7.46	5.7	14	80	13.5	0.26	0.62	0.067	5.3
23	1.80	6.61	2.3	14	84	16.3	0.00	1.04	0.103	5.8
24	1.09	7.95	1.6	12	86	12.5	0.98	0.81	0.104	4.5

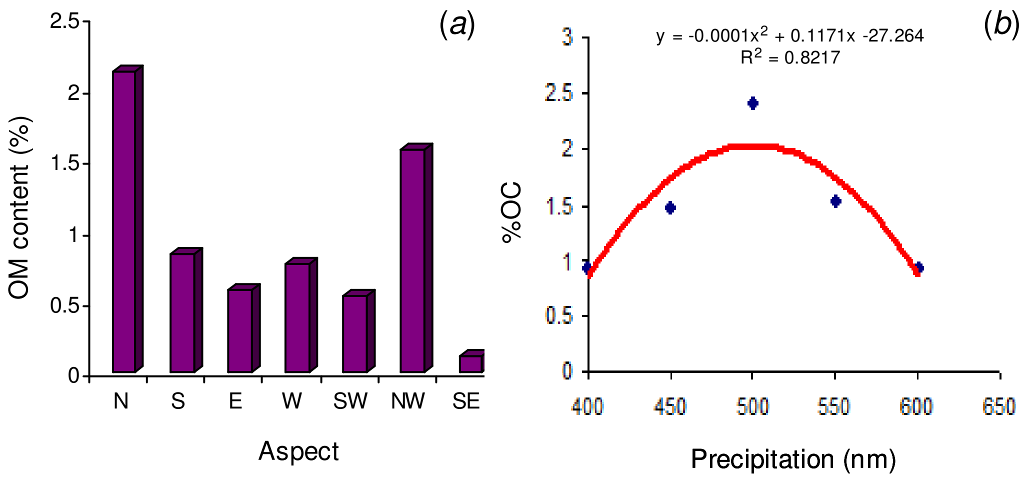

Figure 2. Relationship between soil OM and aspect (a left) and relationship between soil OC and precipitation (b right).

Conclusion

Comparison of soil OC contents for different geographical aspects showed that the highest OC contents belong to the northern and north-western aspects in all elevation and precipitation classes (Figure 2a). These results show that an overall conservation and management program must consider specific bio-eco-physical conditions of each site to be comprehensive. For a successful soil carbon sequestration program we should pay attention to all environmental aspects involved in increasing biomass yield, site specific programming and soil carbon sequestration.

References

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