**Carbon Sequestration Potential of Soils in Different Land Use Types**

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**Abstract**

The increase in carbon emissions as a result of the effect of global warming is an important threat. Reconnection of carbon, which has an effect on global warming, to the soil has attracted the attention of researchers in recent years. In this study, the status of carbon sequestration potentials of surface soils in different land uses (Agriculture, Pasture) and their relations with some soil properties were evaluated. The organic carbon contents of the soils were determined in the range of 0.081- 3.98%. The carbon sequestration potential of pasture soils was determined between 46.02-110.46 tons C ha-1, and this value was determined in the range of 28.70-88.46 tons C ha-1 in agricultural areas. Low positive correlations were obtained with soil carbon sequestration potentials, field capacity and wilting point moisture content, and low negative correlations with organic C. While the carbon sequestration potential showed a positive correlation(r:0.85; p<0.01) for particles smaller than 20 μm, it showed a statistically significant negative (r:-0.80; p<0.01) correlation with sand particles. As a result of the study, it was determined that the higher level of organic carbon in the pasture soils led to a lower level of carbon sequestration potential. It has been evaluated that with the increase of organic C amount in agricultural soils, carbon sequestration will increase and carbon sequestration potential will decrease.

**Key words:** Organic carbon,land use, soil physical properties

**Introduction**

One of the most important parameters affecting the quality and sustainability of soils is soil organic carbon (SOC). Soil and plants are the most important organic carbon scavengers in terrestrial ecosystems (Janzen, 2004). Organic carbon stocks, which are kept in the soil for a long time under suitable conditions, are decreasing due to factors such as changes in land use, tillage techniques, erosion and different cultural managements. (Yılmaz and Dengiz, 2021). The most effective way of regaining the carbon released into the atmosphere from the soil is to bind the carbon back to the organic structure. When organic matter is decomposed, carbon-containing greenhouse gases are released into the atmosphere and the continuity of this situation emerges as a contribution to global warming (IPCC, 2014). Total organic fraction of SOC; Microbial biomass contains part of organic compounds and minerals containing plant residues at different stages of decomposition and stabilization (Ćirić et al., 2016). In general, SOC contains humic substances and unstable soil organic matter. Humic substances are substances of a stable nature that are specific to each soil and do not change significantly over decades of soil use. Carbon sequestration is the process of storing free atmospheric carbon dioxide in the soil as organic matter by plants through photosynthesis.

Changing environmental conditions have an impact on the organic matter content and amount of organic carbon in the soil. Post and Kwon (2000) stated in their studies that approximately 33.8 or 33.2 g cm-2 carbon can be stored per year by converting an agricultural area into a forest or pasture area. Land use techniques are considered as an important function in soil organic carbon sequestration in terms of land cover and types. Understanding the impact of different land use management on soil organic matter content and composition is extremely important for the management of soils for atmospheric CO2 (Guo and Gifford, 2002; Murty et al., 2002). Saviozzi et al. (2001) compared the organic C content of the soils in the grain-grown land, poplar and natural pasture land. As a result of this study, it was reported that the organic carbon content of the field where grain production is made is 70% less than that of pasture land and 60% less than that of poplar. Again, Yılmaz and Dengiz examined the organic carbon stocks of soils in different land use types and determined the forest lands with the highest C stock, while the others were determined as pasture and agricultural land, respectively.

In this study; It is aimed to evaluate the relationship between the C sequestration potentials of soils on different land uses (agricultural land, pasture) and some soil properties.

**Material and Method**

**Materiel**

The study area is located within the borders of Isparta city center in the Western Mediterranean Region.whose spatial coordinates are WGS84/UTM 36N (Şekil1).  According to Corine 2018 land classification, land use Forest and Semi-Natural areas cover 64.72% (50085.86 ha), agricultural areas cover 29.62% (22922.3 ha), Water bodies 0.1% (80.26 ha) and artificial zones 5.55% (4298.01 ha).

Isparta is a province located at the western foot of the Taurus Mountains. As a result of the compression of Taşeli and Tepeli plateaus, folds and then shapes were formed by tectonic and volcanic movements. Basalt and trachyte deposits have emerged as a result of volcanic movements, and the oldest structure belongs to the Paleozoic (1st time). (Anonymous, 2018). The province of Isparta is located in the transition zone between the Mediterranean climate and the Central Anatolian climate. A temperate climate prevails in the hollows to the south of the Taurus Mountains, and a cooler and rainier climate prevails as the altitude increases towards the Taurus Mountains. Most of the precipitation is in the winter and spring months, and the precipitation and humidity; varies depending on altitude, proximity to the sea and roughness. The hottest months in Isparta are July and August, and the coldest months are January and February. The prevailing wind direction in the province, which is in the center of the Lakes Region, is southeast. According to the meteorological data for many years (1929-2021), the average temperature was determined as 12.3 °C and the annual precipitation was 568.4 mm (TSMS, 2022).

In the study area, 20 agricultural lands and 24 pasture lands (44 sampling points) were studied. Isparta oil rose cultivation, dry agriculture, orchard and vineyard cultivation are widely practiced in the agricultural lands of the region.

**Method**

Disturbed and undisturbed soil samples were taken to represent 0-20 cm depth at the sampling points. The methods of the properties examined in the soils are given below.

Mechanical analysis: Percentages of sand, silt and clay in soil samples were determined by the bouyoucos hydrometer method (Burt,2014).

Organic carbon: Determined using the modified Walkley-Black method (Burt,2014).

Moisture constants: The field capacity (0.33 atm) and the moisture retained at the wilting point (15 atm) were determined by the volume of the undisturbed samples with the help of the ceramic-plated pF set (Burt, 2014).

The carbon sequestration potentials of the soils were determined according to Equation 1. (Angers et al., 2011; Cao et al., 2016).

$C\_{SP} =S\_{def}×γ×D×(1-d\_{2-mm}/100)×10^{–1}$ (Eq.1)

Where γ is the bulk density (g cm–3), D is the soil depth (cm) and d2-mm (%) is the >2-mm coarse fraction of the soil, Csp: The carbon sequestration potential (CSP, t C ha–1), Sdef : remaining deficit to saturation, Sdef = Csat – *a.*TOC , where *a* is the ratio of soil organic carbon (<20 μm) in total SOC, Csat: , the saturated soil organic carbon (Csat, %) associated with < 20 μm

Spearman correlation matrices were used to evaluate the relationships of soil properties. In addition, descriptive statistics and correlations of soil properties were carried out using the IBM SPSS Statistics 23 package program. R software and ggplot2 package (library) were used to create the Violin plot graphics of the obtained values.

**Result and Discussion**

Descriptive statistics of soil properties are given in Table 1. The sand, silt and clay contents of the pasture soils were found in the ranges of 10.08-64.61%, 11.65-55.79% and 21.03-61.18%, respectively. Of these soils, 54.16% clay, 8.33% clay loam, 16.66% sandy clay loam, 8.33% silty clay, 4.16% silty clay loam, silty loam and loam texture class. Sand, silt and clay contents of soils for agricultural areas are 9.37-78.4%, 11.15-70.41% and 6.00-49.49%, respectively. The texture classes were determined as 20% clayey loam, 15% sandy loam, 10% clay, 15% loam, 10% sandy clay loam, 5% silty clay loam and silty loam, 10% silty clay and loamy sand.

Compared to agricultural lands, the texture groups of pasture soils were determined as heavier. While the data sets obtained in both groups were distributed close to normal, the variances of the textural fractions from the mean were higher for the pasture areas. In the agricultural and pasture lands, the bulk density values varied between 1.13-1.89 g cm-3 and 1.19-1.69 g cm-3, respectively, while the organic carbon contents were found to be 1.73% and 1.13% on average. Organic carbon contents were determined to be higher in pasture soils. Insufficient attention paid to unconscious tillage and organic matter additions in agricultural lands leads to these results. Yılmaz and Dengiz (2021) determined that the organic carbon stocks of the soils are higher in the pasture areas compared to the agricultural lands. Organic C content was determined as having the highest coefficient of variation among soil properties. In addition, it was determined as the feature that exhibits the furthest distribution from the normal.

Table 1. Descriptive statistics of soil properties

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Variable | Mean | StDev | CoefVar | Minimum | Maximum | Skewness | Kurtosis |
| Agriculture |
| Clay % | 41.87 | 11.64 | 27.81 | 21.03 | 61.18 | -0.2 | -0.82 |
| Silt % | 29.07 | 13.15 | 45.22 | 11.65 | 55.79 | 0.64 | -0.68 |
| Sand % | 29.06 | 14.53 | 50.01 | 10.08 | 64.61 | 0.97 | 0.28 |
| Bulk density g cm-3 | 1.42 | 0.01 | 11.88 | 1.13 | 1.89 | 0.22 | 0.85 |
| Organic Carbon %  | 1.73 | 0.80 | 46.37 | 0.480  | 3.14 | 0.98  | -0.83 |
| CSP t C ha-1 | 68.05 | 24.17 | 35.52 | 28.70 | 88.46 | -0.31 | -1.15 |
| Field Capacity % | 36.23 | 6.42 | 17.71 | 27.37 | 49.55 | 0.41 | -0.92 |
| Wilting Point % | 23.04 | 6.89 | 29.92 | 9.06 | 35.69 | 0.03 | -0.49 |
| Pasture |
| Clay % | 26.47 | 12.22 | 46.16 | 6.00 | 49.49 | 0.04 | -0.78 |
| Silt % | 31.69 | 14.33 | 45.22 | 11.15 | 70.41 | 0.80 | 1.28 |
| Sand % | 41.84 | 22.43 | 53.62 | 9.37 | 78.4 | 0.27 | -1.02 |
| Bulk density g cm-3 | 1.40 | 0.01 | 9.51 | 1.19 | 1.69 | 0.11 | 0.13 |
| Organic carbon % | 1.13 | 0.82 | 72.23 | 0.08 | 3.98 | 1.85 | 5.30 |
| CSP t C ha-1 | 84.37 | 16.8 | 19.91 | 46.02 | 110.46 | -0.3 | -0.44 |
| Field Capacity % | 32.37 | 9.7 | 29.96 | 14.79 | 50.15 | -0.02 | -0.85 |
| Wilting Point % | 23.04 | 6.89 | 29.92 | 9.06 | 35.69 | 0.03 | -0.49 |

The violin plot image of the variability in carbon binding potential due to different land uses (LU) is shown in Figure 1. The carbon sequestration potential was found to be 46.02-110.46 t C ha-1 in pasture soils (P), and 28.70-88.46 t C ha-1 levels in agricultural lands (A). Both data sets showed a distribution close to normal. The coefficient of variation was determined to be higher in agricultural soils. The negative skewness coefficient in both data sets is a result of higher values in the distribution than the mean. Violin chart also shows that there are backlogs for both data sets in the 3rd quarter.

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Figure 1. Carbon sequestration potentials for different land use types

Violin chart is one of the most effective methods for visualizing the distribution and probability density of data. While the median values were higher in the pasture lands, the general trend in the data set was determined close to the median level. While the median is in the middle of the data of the variables, the first quarter represents the region between the median and the minimum, and the third quarter represents the region between the median and the maximum. Although it is seen that there are trends in the data set in the 3rd Quarter part of agricultural lands, their carbon sequestration potential was determined at a lower level compared to pasture areas.

The relationship between the Csp properties of the soils and the amount of <20 µm (Silt+clay) fractions is given in Figure 2. A positive statistically high level correlation was determined between the two features (r = 0.85; p>0.01). Studies have shown that the C sequestration potential of soils is positively correlated with <20 µm fractions (Angers et al., 2011; Cao et al., 2016). It is thought that sequestration can occur especially by forming complexes with clay.

Figure 2. Relationship between CSP property of soils and fractions < 20µm

The graph showing the linear relationship between the sand contents of the soils and the CSP contents is given in Figure 3. A statistically significant negative correlation was determined between the two features (r = -0.80; p<0.01). Studies have shown that the fine fraction plays a more effective role in the C sequestration potential of soils (Angers et al., 2011; Cao et al., 2016), and it is expected that a negative relationship with the coarse fraction will be determined from this spectrum.

Figure 3. The relationship between the CSP property of soils and the sand fraction

The relationships between the C sequestration potentials of the soils and their moisture constants are given in Figures 4 and 5. The correlations obtained for both field capacity and wilting point were quite low and statistically insignificant. Their low level of positive correlation was evaluated as the increase in the said moisture constants as the fine fraction increased. Studies have shown that the carbon sequestration potential of soils will increase with the addition of organic matter and increases in clay + silt content (Islam et al. 2014).

Figure 4. The relationship between CSP characteristics of soils and field capacity

Figure 5. The relationship between CSP property of soils and wilting point

Paustian et al. (2019) stated that by increasing organic matter in agricultural land and pasture areas, the carbon sequestration potential will increase significantly. Soil texture, clay mineralogy, mineral-organic matter relationship affect the life of C in soil (Paustian et al., 2019). Cao et al. (2016) determined that the carbon sequestration potential is affected by the soil physicochemical properties, climate and land, and the most important feature associated with the carbon sequestration potential is the soil humic substance concentration.

**Conclusion**

In this study, the carbon sequestration potentials of soils in different land use types were examined and their relations with some other soil properties were revealed. As a result of the study, it has been determined that the carbon sequestration potential of the soils is higher due to the organic matter contents and heavy texture in the pasture soils. The C sequestration potentials of the soils showed a positive correlation with the fine fraction (<20µm) and a negative correlation with the coarse fraction (sand). However, significant relationships between soil moisture constants could not be determined.

As a result of the study, it was revealed that organic matter content should be increased in agricultural lands where soil management and land use are effective on C binding potential.

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