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Full Length Research Paper

Organic carbon organic matter and bulk density relationships in arid-semi arid soils in Southeast Anatolia region

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Soil organic matter (SOM) and soil organic carbon (SOC) constitute usually a small portion of soil, but they are one of the most important components of ecosystems. Bulk density (dB or BD) value is necessary to convert organic carbon (OC) content per unit area. Relationships between SOM, SOC and BD were established in weak alkaline clay fractions of agriculture soils in Southeast Anatolia Region in Turkey. The importance of such relationships results from using sample and rapid techniques to estimate SOC-BD and SOM-BD relationships. Between SOM and SOC, the positive strongest relationship for three models (R^2=0.9976; 0.9982; 94.64) were detected. For SOM-BD and SOC-BD, negative relationship for three models were determined (R^2=0.1342; 0.1420; 0.1329 and R^2=0.1266; 0.1252; 0.1378 respectively). The mismanagement and land cultivation in the past and present causes soil degradation. Therefore, the soil organic matter and carbon are now below their potential level. Evaluation of their stocks requires knowledge about BD. BD is affected by factors such as water, aeration status, root penetrate, clay content, texture, land use and management, therefore it is a very important soil parameter.

Key words: Soil organic carbon, soil organic matter, soil bulk density, arid-semi arid soils.

INTRODUCTION

Soils are important component of the global carbon cycle. Soil organic carbon (SOC) stocks are the largest reservoirs in the world. SOC plays important role in alleviating the effects of greenhouse gases and storing, and it is necessary for enhancing soil quality, sustaining and improving food production, maintaining clean water and reducing CO_2 in the atmosphere. In the past, soil organic carbon concentration was measured to evaluate soil "quality" (Gregorich et al., 1994), and recently, people perspective about it has changed.

One of the soil properties necessary to predict the change, flow and concentration of nutrients in the soils is bulk density (dB) (Bernoux et al., 1998). Increased awareness of the threats of global warming, the effect of greenhous e and mostly the environmental conditions, resulted in researchers focusing on carbon stocks and their flows within the soil. The organic matter in soil can evolve as the source of carbon dioxide or carbon storage in the atmosphere (Lugo and Brown, 1993). Post et al. (1982), Eswaran et al. (1993) and Batjes (1996) said that the world's mineral soils contains 1500 Pg C. The organic carbon stocks of the soils of the Southeastern Anatolia Region were fixed as 0.63 Pg at 100 cm depth, while the inorganic carbon stocks were determined as 1.41 Pg C. To estimate these pools correctly, we need to determine the organic carbon contents and bulk density of the soils (Sakin, 2010). Generally, the soils in tropical regions are characterized by low dB (Bernoux et al., 1998).

Soil organic carbon, soil organic matter (SOM) and their correlation with dB are frequently used to estimate carbon sinks (Post et al., 1982). It is indicated that BD values are necessary for laboratory analyses; and as soon as SOM increases, BD decreases and vice versa (Curtis and Post, 1964).

Jeffrey (1970) also stated that the inversely correlation

Abbreviations: SOM, Soil organic matter; **SOC,** soil organic carbon; **dB,** bulk density; **OC,** organic carbon**.**

Table 1. Statistical analysis of SOM, SOC and dB;

Parameter	N	x±Sy	t	95% CI
SOM	230	0.8367±0.0342	24.473***	0.7691-0.9044
SOC	230	0.4655±0.0207	22.508***	0.4246-0.5064
dB	230	1.3109±0.0266	492.841***	1.3057-1.3162

N, number of soil sample.***p<0.001.

between SOM and BD is normal. The objective of the study was to establish for clay soil sampled in arid-semi arid areas of southeast Turkey, relationship between: (i) SOC and SOM, (ii) SOC and BD, and (iii) SOM and BD.

MATERIALS AND METHODS

To achieve this goal, samples were obtained from arid-semi arid agriculture soils and nearly same parent material. The study area was between 38° 48´ to 39°12´ E longitudes and 37° 09´ to 36° 42´ N latitude in south Turkey. The mean latitude ranged between 375 and 550 m above sea level, with annual highest temperature of 35°C and lowest temperature of 4.9°C. Mean annually precipitation vary between 375 to 450 mm, with total evaporation ranging from 61.0 to 421 mm (mean 2022 mm) (TSMS, 2008).

230 soil samples were taken in agricultural lands and genetic horizons. The soil samples were air-dried, gently ground and sieved through a 2-mm sieve. The bulk density (Mg m^{-3}) was measured (Black, 1965) with a core sampler and rings (with a fixed volume of 100 cm^{-3}; high=6 cm; diameter=5.3 cm) at each soil horizon horizontal stratum (1 meter depth). Samples were dried at 105°C for 24 h. Soil organic matter was measured by Fe_2SO_4 titration of an acid-dichromate digestion (Walkley and Black, 1934) and soil organic carbon was calculated using Equation 1.

$$SOC = 0.58 \times SOM \quad (1)$$

Where, SOC is the soil organic carbon concentration and SOM is the soil organic matter concentration determined by dry combustion. 0.58 is the Van Bemmelen value generally used to convert SOM to SOC. The mathematical relations of these models are as follows:

$$\text{Linear: } y = ax + b \quad (2)$$

$$\text{Logarithmic: } y = ax^2 + bx + c \quad (3)$$

$$\text{Polynomial: } y = ax^3 + bx^2 + cx + d \quad (4)$$

Where, a, b, c, d are models parameters. Statistical analyses were performed using SPSS 9.0 (SPSS, 1993). Correlations of data were statistical of the test.

RESULTS AND DISCUSSION

Relationships between SOM and SOC

Soil organic carbon contained 55 to 58% of organic carbon. Relationships between SOM and SOC were statistically important (p<0.001) (Table 1). SOC was highly correlated with SOM and it could be estimated from the below regression.

$$SOC = 0.565 \times SOM \ (R^2 = 0.99, p<0.001) \quad (6)$$

The factor for converting SOC to SOM is given by our Equation 6, that is, 0.565 ± 0.0019. Similar results (0.472 ± 0.007) were reported by researches by Perie and Ouimet (2007), and David (1988) (0.51 to 0.65). The best model predicting SOC/SOM ratio value is shown polynomial by Figure 1. The relationships between SOM and SOC were positively correlated which means that SOC or SOM increases with increasing concentration of SOM or SOC. According to our study, the best fit between SOC and SOM was determined using three models (Figure 1), such as polynomial, linear and logarithmic.

Perie and Ouimet (2007) also found a strong relationship between SOC and SOM. It has been indicated that SOC/SOM ratio varies depending on soil type (Jain et al., 1997) and soil depth (Westman et al., 2006).

Relationships between soil organic matter and bulk density

In soil science, two models forms are used to predict soil BD from SOM concentration. One of these includes polynomial models developed by Curtis and Post (1964), Federer (1983) and Huntington et al. (1989) while the other form was developed by Federer et al. (1993), Post and Kwon (2000), Tremblay et al. (2002) and Prevost (2004); is non-linear. In this study, we tested three models form for SOM and dB relationships. Their strong dependency was determined according to our study's results (Figure 2). This negative correlations was statistically significant (p<0.001) (Table 1).

Similar results were found by other authors such as Curtis and Post (1964), Federer (1983), Huntington et al. (1989), Federer et al. (1993), Post and Kwon (2000), Tremblay et al. (2002), Prevost (2004), Mestdagh (2006) and Sakin et al. (2011). Jeffrey (1970) found that negative relationships between SOM and BD might be a universal opinion. Bulk density has been frequently related to SOC in soil storing large amounts of SOM (Grigal et al., 1989; Huntington et al., 1989; Arrouays and Pelissier, 1994; Howard et al., 1995).

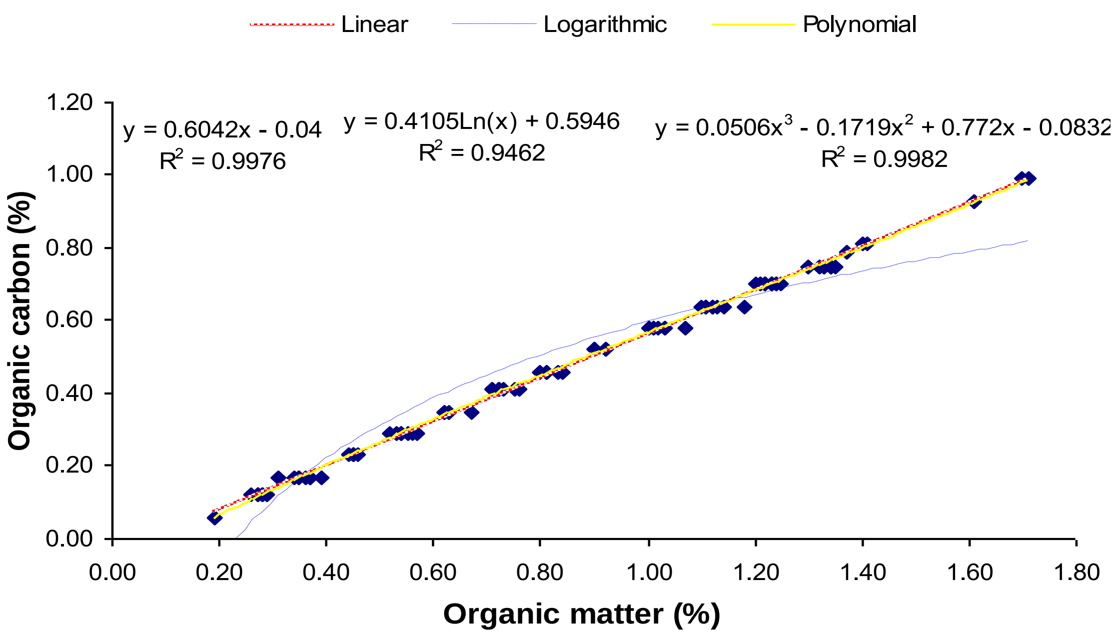

Figure 1. Relationships between organic carbon and organic matter.

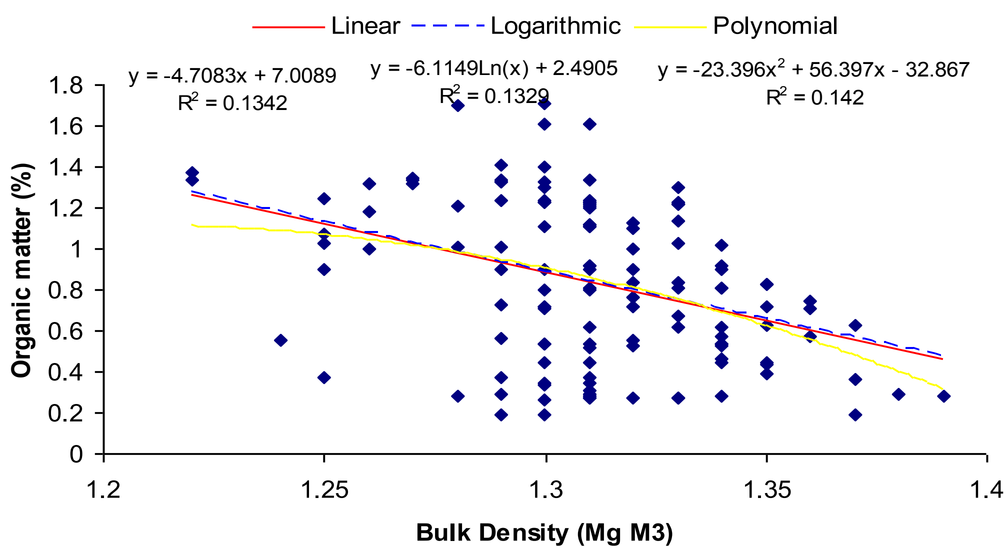

Figure 2. Relationships between bulk density and organic matter.

Relationships between soil organic carbon and bulk density

For our study, the best fit between SOC and BD using the models (linear, logarithmic and polynomial) is given in Figure 1. In this study, relationship between SOC and BD was estimated, and SOC and BD had found strong correlation (Figure 3). There was no statistical significant relationship between SOC and BD ($P<0.001$) (Table 1), that is, the relationship was negative. Also, other authors (Avnimelech et al., 2001; Menounos, 1979; and Sakin et al., 2011) obtained similar results.

Conclusion

(i) Relationships among SOM, SOC and BD are used to estimate soil C pools; these parameters will be used in

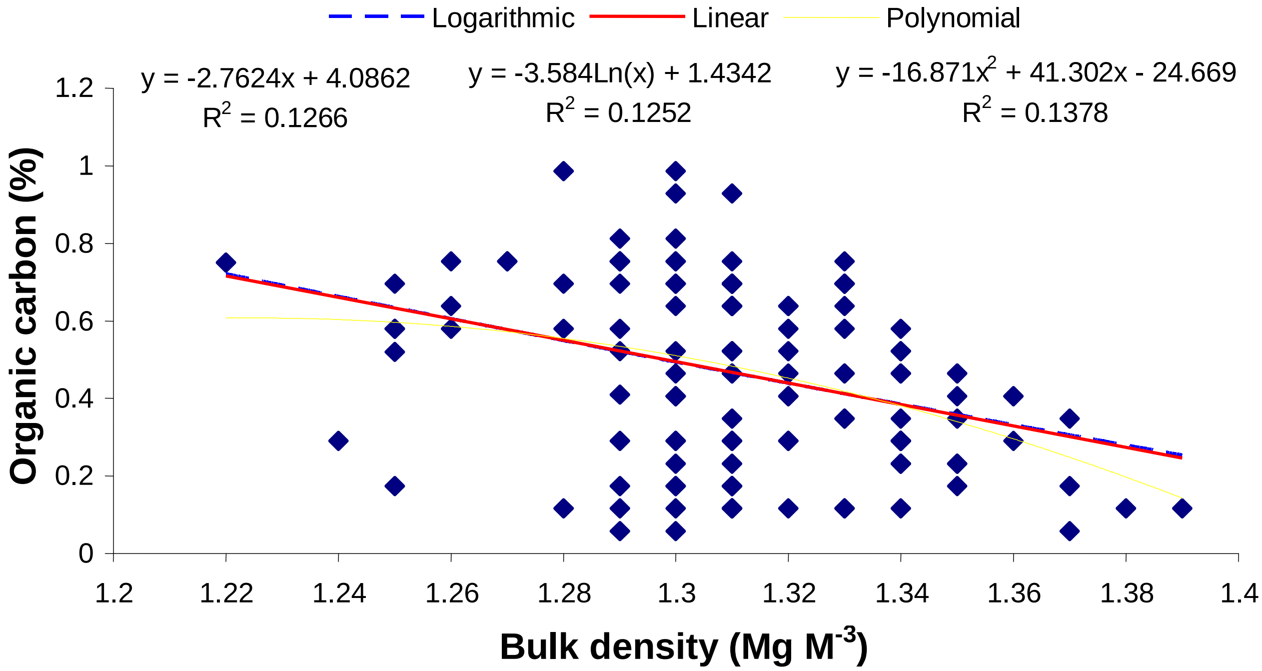

Figure 3. Relationships between bulk density and organic carbon.

future researches.

(ii) In practice, methods to measure BD are labor intensive and time–consuming, so improvement of new methods for measurement is required.

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