Determination of soil organic carbon concentration in agricultural fields using a handheld spectroradiometer: Implication for soil fertility measurement

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Abstract: The soil organic carbon (SOC) plays a vital role in plant growth and development and therefore, is considered as one of the most important indicators of soil quality. This study was carried out in the central region of Saudi Arabia to explore the potential of spectroscopy in determining the SOC concentration in low-fertility soils. Spectral reflectance data was collected, under the controlled laboratory conditions on 39 air-dried 2.0 mm sieved soil samples, using a handheld spectroradiometer of a wavelength range between 350 nm and 2500 nm in the direct contact probe mode. The concentration of the SOC was determined using the Walkley and Black (W&B) and the UV-VIS spectrophotometric methods. The increase in the concentration of SOC was associated with a decrease in the corresponding spectral reflectance. Regression analysis showed linear relationships with high significant correlation between the spectral reflectance and the SOC measured by both the UV-VIS (Model-1: R^2=0.46, p=0.00015 and *RMSE*=6.6 g/kg) and the W&B (Model-2: R^2=0.48, p=8.92E-05 and *RMSE*= 2.8 g/kg) methods. For these models, two wavebands with wavelengths of 2167 nm (Model-1) and 1359 nm (Model-2) were identified as the most sensitive bands to the SOC concentration. The cross-validation confirmed the validity of Model-1 with R^2, p and *RMSE* values of 0.50, 0.0099 and 6.6 g/kg, respectively. The validation results of the Model-2 showed values of R^2, p and *RMSE* of 0.72, 0.00023 and 4.0 g/kg, respectively. Results of this study revealed the possibility and the potential of using the spectral reflectance technique in predicting the concentration of SOC.

Keywords: soil fertility, organic carbon, modeling, spectroscopy, reflectance
DOI: 10.25165/j.ijabe.20181106. 4061

Citation: Tola E, Al-Gaadi K A, Madugundu R, Kayad A G, Alameen A A, Edrees H F, et al. Determination of soil organic carbon concentration in agricultural fields using a handheld spectroradiometer: Implication for soil fertility measurement. Int J Agric & Biol Eng, 2018; 11(6): 13–19.

1 Introduction

Soil organic carbon (SOC) refers to the carbon stored in the organic fraction of the soil, i.e. soil organic matter (SOM), excluding fresh and un-decomposed plant materials, such as straw and litter lying on the soil surface[1]. SOC is commonly expressed as the percentage of carbon weight to the total weight of dry soil. There are several direct and indirect methods available in the literature for the determination of the SOC. The amount of the SOM in the soil mainly depends on the soil condition, current and previous vegetation cover, topography, hydrological condition and farm management practices[2]. The SOC is considered as one of the most important soil components that plays a vital role in the plant growth and development processes, as a source of energy and nutrients for soil microorganisms. Therefore, the SOC is viewed as the most important indicator of soil quality[3]. The importance of maintaining high levels of SOM or SOC is to improve the soil physical properties (e.g. reducing soil bulk density and soil compaction and increasing aggregate stability), conserve soil water, improve biological activities and increase the available nutrients, which all lead to a significant increase in the biomass and crop yield[3]. Although the SOM is generally present in relatively small amounts (typical agricultural soils contain 1%-6% organic matter), it is the key to build and maintain healthy soil. Through its significant positive effect on most of the basic soil properties, every 1% increase in the SOM was observed to increase about 12% of the potential crop-yield[4]. In general, the SOM is the most important component of the agricultural soil and is considered as the key index of soil fertility.

Agricultural practices significantly contribute to the SOC loss through different mechanisms including deforestation, biomass burning, drainage, soil tillage, removal of crop residues, summer fallow and improper use of pesticides and other chemicals[5]. Therefore, estimation of the SOC concentration in agricultural soils at an acceptable level of accuracy is important, especially in the case when SOM exhibits strong spatial dependence and its measurement is time and labor-intensive procedure. Hence, there is an urgent need to develop rapid and inexpensive soil

Received date: 2017-12-19 **Accepted date:** 2018-05-06
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