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## The App SOC plus a tool to estimate and calculate organic carbon in the soil profile

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### Abstract

In the world, researchers are working very intensively in the development of soil organic carbon (SOC) inventories. Soil organic carbon is very important because it constitutes the largest reservoir of carbon in terrestrial ecosystems. Maintaining and increasing soil carbon is an option to reduce the amounts of CO<sub>2</sub> in the atmosphere, and thereby, to reduce or mitigate climate change. The SOC is now a topic of great interest hence it is recommended to know the amount of SOC along the profile to select and evaluate those areas that should be preserved. The aims of developing App SOC plus were to eliminate the calculate errors of SOC and to make a tool to estimate SOC in field. The common units of measurement of soil properties were employed: bulk density in mg mL<sup>-1</sup>, horizon thickness in centimetres, stoniness and organic carbon in percentage. The App SOC plus was developed in the Android platform. App SOC plus involves a three-step process: introduction of soil properties, calculation of SOC to horizon and soil profile, and conversion of units using the international and English systems. As a result, there will no longer be confusions with conversion units using App SOC plus; with App SOC plus the soil organic carbon can now be calculated or/and estimated because it provides instructions (aids) to estimate the soil properties necessary to calculate the SOC in the soil profile. You can save time in the calculation of SOC. App SOC plus is a tool for diagnosis in the field.

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**Keywords:** Carbon stock; Organic matter; Android application; Bulk density; Stoniness

### 1. Introduction

Intensive work is developed at a global, national and local level to elaborate the inventories of soil carbon because of its relation to the global climate change. Soil carbon is considered the largest carbon reservoir of the terrestrial ecosystems (Alvarez-Arteaga, Krasilnikov, & García-Calderón, 2012.) At a local level, areas of interest for the conservation may appear, such as the natural protected areas, the national parks and the biosphere reserves. These areas are valued because of the environmental services they offer to the society. The payment

for these environmental services, among which the fixation of organic carbon stands out, is planned in some of these places the soil organic carbon calculation (Pérez, Ramírez, Bautista, & Jaramillo, 2013).

The study of soil organic carbon is now a subject of great interest, which is why it is recommendable to know the amount of soil organic carbon throughout the soil profile to select and value the areas that must be preserved.

Normally, miscalculations are shown in scientific meetings because of the unfortunate selection of the properties of the soil that is being measured, the way of expressing them with inappropriate units and because of miscalculations. Besides, the number of professionals who are not edaphologists interested in the measurement of SOC grows day by day.

The reasons to create App SOC plus are as follows: (a) normally, miscalculations are shown in scientific meetings because of the unfortunate selection of the properties of the soil that is

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being measured, the way of expressing them with inappropriate units and because of miscalculations; (b) the number of professionals who are not edaphologists interested in the measurement of SOC grows day by day; (c) the need to perform rapid field estimations.

The aims behind the creation of App SOC plus are (a) to decrease the miscalculations caused by the unfortunate selection of the properties of the soil, the application of the wrong equation and the inappropriate units, in which the results are expressed; (b) to offer the professionals who are not edaphologists a tool to measure the SOC; (c) to perform rapid field estimations.

## 2. Materials and methods

### 2.1. App design and development platform

App SOC plus is an application designed for the estimation of soil organic carbon from its edaphic properties. This app is compatible with all mobile devices with an Android V 4.0 or the latest operating system. In order to create App SOC plus we used: (a) SDK, the software developer tool for Android and (b) IDE Eclipse as an integrated development environment. Both are open access tools. Interfaces were designed to allow compatibility with resolution in smartphones and tablets of 7' and 10' (Canós, Letelier, & Penadés, 2003).

### 2.2. Soil organic carbon calculation

In order to calculate the soil organic carbon (SOC) the following formula is applied:

$$\text{SOC} = \sum_{i=n}^{i=1} \left( \left[ \left( BD_i * (TH_i * 0.01) * \left[ 1 - \frac{CR_i}{100} \right] \right) * C_i \right] * 100 \right)$$

where SOC [ $\text{Mg ha}^{-1}$ ]: organic carbon full profile;  $n$ : total number of horizons full profile;  $BD_i$  [ $\text{g mL}^{-1}$ ]: bulk density of the horizon  $i$ ;  $TH_i$  [cm]: thickness of the horizon  $i$  in cm;  $CR_i$  [vol.%]: volume of coarse fragments by horizon  $i$ ;  $C_i$  [%]: percentage of organic carbon horizon  $i$ .

App SOC plus includes a simplified formula, in which the soil properties are shown in the common units in use.

App SOC plus makes it possible to calculate the organic carbon in an easy and rapid way. It is also possible to carry out estimations of the quantity of organic carbon by using the soil profile description on the field (it includes options for the estimation of the bulk density, stoniness and organic carbon on the field).

### 2.3. Bulk density estimation

The bulk density is measured with a cylinder of a known volume which is inserted in each horizon, then it is dried and weighed right after (Jahn, Blume, Asio, Spaargaren, & Schad, 2006; Siebe & Jahn, 1996). When the horizon has a reduced thickness or it is too compact to insert the cylinder properly, it is possible to measure the soil density by means of the aggregate density by using the clod method (Gandoy, 1992; NOM,

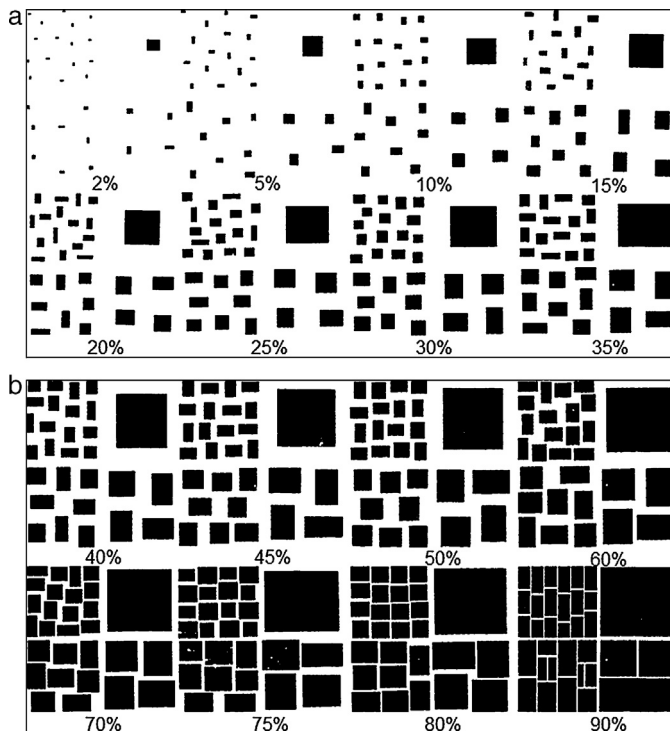


Fig. 1. (a) Images to estimate stoniness percentage in volume. (b) Images to estimate percentage in volume stoniness.

2003.) In non-aggregated soils, it is recommended to use the core method (Gandoy, 1992).

In stony soils, such as the ones on the Yucatan Peninsula, which have high carbon content in fine earth but, at the same time, have scarce fine earth, it is necessary to measure the bulk density by digging a hole in the soil and collecting fine earth, thick fragments, and afterwards, measuring the volume by lining a plastic and by filling it with water, or by using the core method.

The key from Table 1 is used in order to make the bulk density estimation on the field.

### 2.4. Horizon thickness measurement

A measuring tape is used in order to obtain a horizon thickness measurement. The difficulty in the process appears when the boundary between the horizons is wavy, irregular or broken. In these cases, the average depth between the horizons must be registered.

The thickness is measured in centimetres.

### 2.5. Stoniness or thick fragments volume

The estimation of the stone fragments volume, also called stoniness, can be carried out by comparison to Fig. 1 (USDA, 2012). The estimation of this parameter is carried out horizon by horizon. It is recommended to work with a known surface (e.g.  $100 \text{ cm}^2$ ) using a cord that would be adaptable to the different horizon thicknesses.

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