Estuarine, Coastal and Shelf Science 317 (2025) 109182

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Development of soil organic carbon quantification model and comparison based on CHN analyser, Loss on Ignition, and Walkley-Black methods for mangrove soils in Madagascar

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ARTICLE INFO

Keywords:
Marine sediment
Organic matter
Blue carbon
Mitigation
Climate change
Adaptation

ABSTRACT

Mangrove ecosystems have a high capacity to sequester and store atmospheric carbon dioxide (CO_2) compared to other tropical forests. Most of this CO_2 is stored as organic carbon in the mangrove soils (50–90%). While quantifying carbon stocks in mangrove trees is generally a straightforward process, quantifying carbon stocks in mangrove soils can be difficult and expensive due to the lack of analytical equipment or the high costs associated with soil organic carbon (SOC) analysers, respectively. The large number of samples coupled with repeated soil sampling required to quantify soil carbon sequestration/burial rates can further inflate these costs. The development of SOC models to quantify carbon content can help resolve these issues and increase the ease of quantifying soil carbon stocks or sequestration rates. We compared different methods to quantify SOC stocks from multiple locations in Madagascar mangroves. A total of 1327 soil samples from 66 plots sampled from the west coast of Madagascar were consecutively analysed with the Walkley-Black (WB), Loss on Ignition (LOI_{400}, LOI_{550}) and CHN analyser methods. These four available methods resulted in significant differences ($p < 0.001$) of SOC values, varying from 1.93 ± 0.04% with CHN, 4.49 ± 0.08% with LOI_{400}, 4.54 ± 0.09% with WB, and 7.33 ± 0.11% with LOI_{550}. As the CHN method is widely regarded as the most accurate method thus, CHN values were used to calibrate and estimate LOI_{400}, LOI_{550} and WB results with linear regression functions. After calibration, the coefficient of regressions resulted in conversion factors of 0.415 for WB, 0.253 for LOI_{400} and 0.157 for LOI_{550}. This study demonstrated the reliability of locally available methods for SOC analysis for mangroves and developed calibration coefficients that can be used to increase the accuracy of SOC methods when CHN analyzers are not available for blue carbon stock assessment.

1. Introduction

Covering an approximate global area of 147,359 km^2 as of 2020, mangrove forests are considered important ecosystems due to the multiple ecosystem services they provide (Bunting et al., 2022). Of growing interest in recent years has been their capacity to mitigate climate change (Tang et al., 2018). Mangrove forests can sequester and store three to five-times more atmospheric carbon than other tropical forests (Donato et al., 2011). Most of this carbon is stored in mangrove soils (50–90%) (Alongi, 2020, Benson et al., 2017; Donato et al., 2011; Kauffman et al., 2020).

Madagascar is home to an estimated 2% of global mangroves and

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https://doi.org/10.1016/j.ecss.2025.109182
Received 12 September 2023; Received in revised form 1 February 2025; Accepted 5 February 2025
Available online 11 February 2025