QUALITATIVE ASSESSMENT OF SOIL ORGANIC CARBON POOLS USING UV-VIS SPECTROSCOPY

ABSTRACT

Soil acts as the niche of Carbon (C). Soil carbon sequestration is of paramount importance for sustaining soil health as well as mitigating global warming. Studies on soil organic C content of both surface as well as deep subsoil are very important. Besides, studies on C in rice soil, as well as non-rice upland soil of tropical India, are also of principal importance. With this background, the present experiment was undertaken to recognize qualitative characteristics of water-soluble soil C in rice soil and non-rice soil along depth using UV-Vis spectroscopy. Soil sampling was done from representative rice and non-rice soil ecologies in West Bengal from 0-20 cm, 100-120 cm and 120-140 cm soil depths. Quality and stability of C can be estimated by studying the nature of absorbance of water-soluble C in UV-visible range. Results indicated a higher absorbance of C in the subsurface than that of surface soil. Similarly, higher absorbance of C was recorded in soil collected from rice ecology compared to non-rice ecology. Irrespective of soil depth, it was noted that there was more humified as well as aromatic C in rice ecologies than that in non-rice ecologies. Thus soil of lower soil depth as well as rice ecologies acts as a better niche for sequestrating C in soil.

Keywords: Soil carbon, rice ecology, non-rice ecology, soil depth, UV-Visible spectroscopy

INTRODUCTION

Soil is kenned as the most immensely colossal terrestrial carbon pool on the Earth where soil organic matter (SOM) constitutes the consequential biologically active form (Bhattacharyya *et al.*, 2013). Organic matter (OM) content in soil plays a paramount role to amend the soil's biological, chemical and physical properties and is also an indicator of the quality and productivity of soils (Lal, 2004; Brahim *et al.*, 2011). In India, the area under rice cultivation is approximately 43.7 m ha. Majorly under submerged rice soil avails methane emission and submerged rice soils are kenned to hold higher magnitudes of resilient C among all terrestrial ecosystems than drylands (Xie *et al.*, 2007; IPCC, 2013). Submerged rice soil have the highest C density and act as a paramount niche for C sequestration in lowland soils, these soils recorded higher C density compared to upland non-rice soils (Xie *et al.*, 2007; Chen et al., 2021; Yan et al., 2011).

Most of the physical and chemical procedures used in assessing DOC characteristics cannot be utilized while assessing the water soluble C present in soil (Simonsson *et al.*, 2005). Thus, utilization of ultraviolet-visible (UV-Vis) absorption spectrophotometry was utilized to categorize the aromaticity, hydrophobic content, and biodegradability of soil organic carbon (SOC) (Hautala et al., 2000; Dilling and Kaiser, 2002; Croué et al., 2003).

MATERIALS AND METHODS

Soil Sampling:

Representative soil samples were collected during 2019-2020 from Gayeshpur, Nadia district of West Bengal from representative rice-rice (Rice ecology) and vegetable-vegetable (Non-rice ecology) cropping systems which were supposed to be existed in that site for at least the last 15 (fifteen) years to have a look on the trend of soil carbon as affected by cropping system and management practices (Carillo *et al.*, 2012). Representative soil samples were collected from five sites of each cropping system from three depths viz., 0-20 cm, 100-120 and 120-140 cm. Thus, a total of 30 (2 cropping systems x 5 sites x 3 depth) representative soil samples were collected from the study sites. The soil samples collected from representative rice and non-rice ecologies were then air-dried, mixed well and passed through a 2 mm sieve for the analysis of water-soluble C and other soil properties. GPS was used for noting the latitude and longitude of the sampling sites.

Spectroscopic analysis dissolved C pools of soil

Spectroscopy has been identified as the most essential tool in studying and characterizing the structure of intricate organic compounds (Wang *et al.*, 2013). The aliphatic and aromatic compounds of DOC can be characterized/estimated by UV-Vis spectroscopy (Li *et al.*, 2010) which is also capable of estimating the hydrophobic content and biodegradability of DOC. Here, absorbance characteristics as well as functional groups as affected by soil depth and rice and non-rice soil ecologies were studied in details. The various wavelengths of light with their property and supporting references are indicated hereunder:

Table 1. The list of wavelengths with their property and reference

Wavelength (nm)	Property determined	Reference
250	Aromaticity, apparent molecular weight	Peuravuori and Pihlaja, 1997

254	Aromaticity	Abbt-Braun and Frimmel, 1999, Hur and Schlautman 2003
260	Hydrophobic C content	Dilling and Kaiser, 2002
272	Aromaticity	Traina *et al.*, 1990
280	Hydrophobic C content, Humification index, Apparent molecular size	Chin *et al.*, 1994, Korshin *et al.*, 1999, Kalbitz *et al.*, 2003
285	Humification index	Kalbitz *et al.*, 2000
300	Characterization of humic substances	Artinger *et al.*, 2000
350	Apparent molecular size	Korshin *et al.*, 1999
365	Aromaticity, apparent molecular weight	Peuravuori and Pihlaja, 1997

RESULTS AND DISCUSSIONS

UV-Vis spectroscopy to characterize water-soluble C pools

While comparing the water-soluble C pools using UV-VIS spectroscopy along soil depths, it showed a higher residence time of C in deep subsoil compared to surface soil layers irrespective of cropping systems studied. Again, the soils of rice-rice cropping systems (rice-ecology) also designated recalcitrant C pool compared to non-rice soil ecologies.

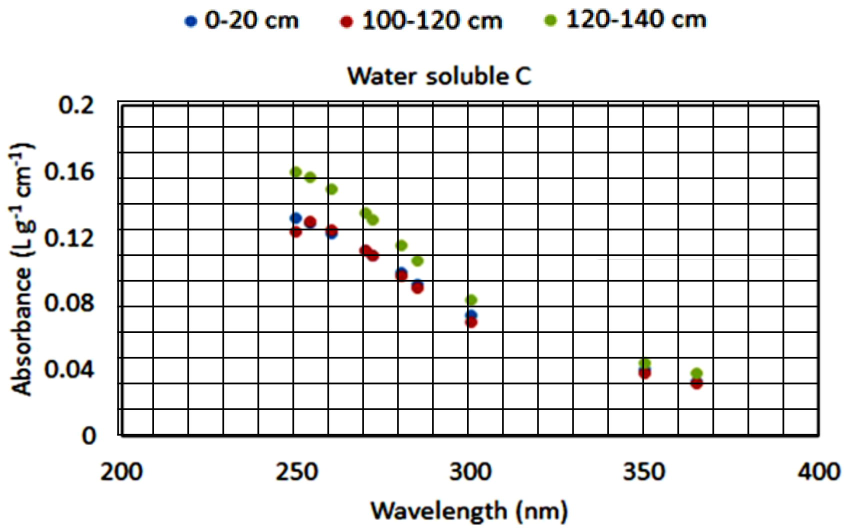

Fig. 1. The absorbance of water-soluble C pool in different soil depths in various discrete points

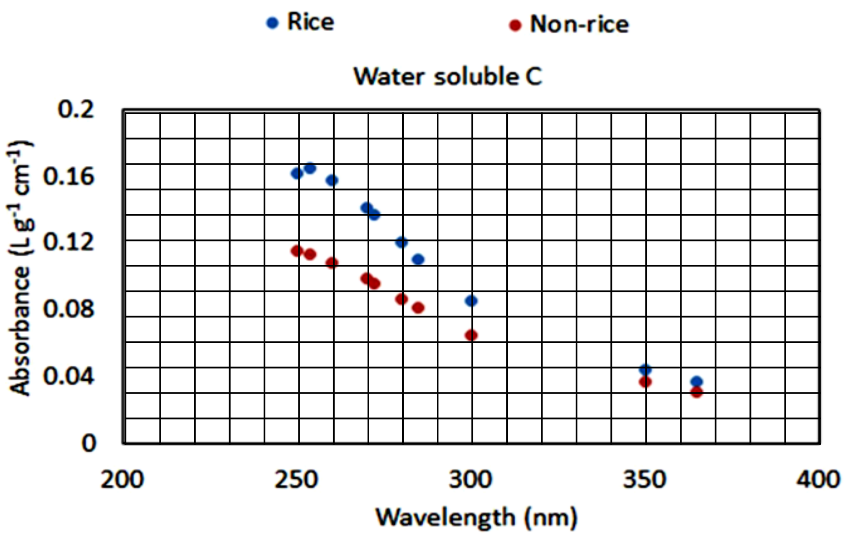

Fig. 2. The absorbance of water-soluble C pool in different soil ecologies in various discrete points

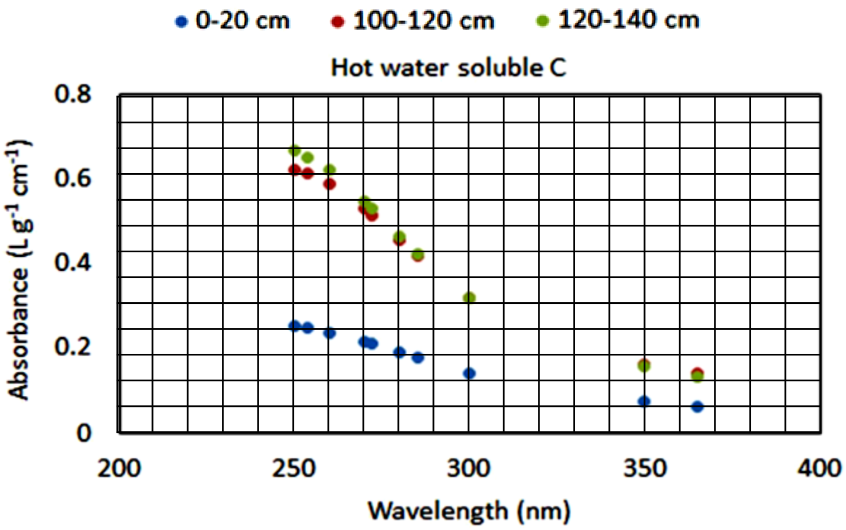

Fig. 3. The absorbance of hot water-soluble C pool in different soil depths in various discrete points

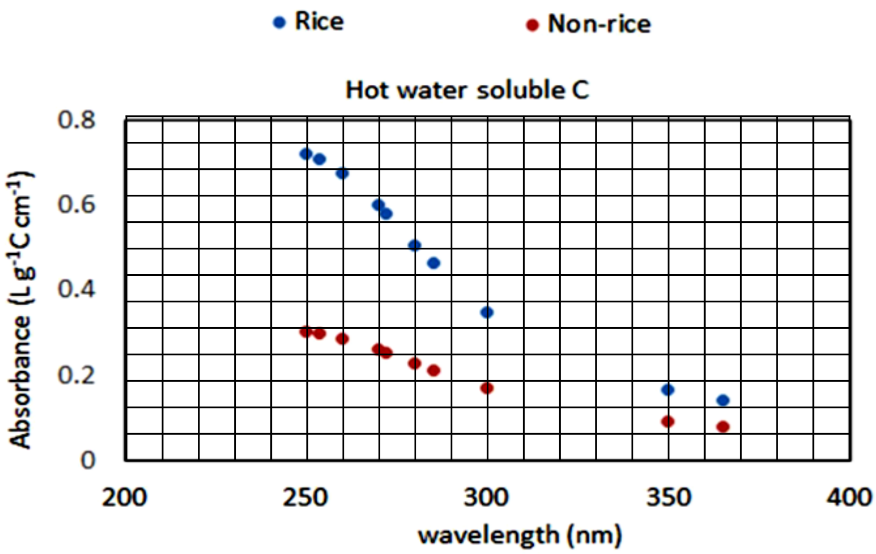

Fig. 4. The absorbance of hot water-soluble C pool in different soil ecologies in various discrete points

Using UV-Vis, estimation of the aromatic moiety is much easier and accurate as UV absorption of organic solutes is directly proportional to their content of aromatic compounds (Traina et al., 1990; Chin et al., 1994). The stability and quality of C in soils can be determined by the absorbance characteristics of water-soluble C pools in different wavelengths (in UV- visible range). The higher aromaticity and larger molecular weight of soil organic matter was noted in higher absorbance in 250, 254, 272, and 365 nm wavelengths (Peuravuori and Pihlaja, 1997; Korshin et al., 1999; Hur and Schlautman, 2003). Similarly, greater absorbance in 260 and 280 nm gives an indication of higher hydrophobic C and greater humification (Chin et al., 1994; Korshin et al., 1999; Dilling and Kaiser, 2002; Kalbitz et al., 2003). Likewise, the molecular size of the organic compounds can be indicated by the absorbance at 280 and 350 nm (Chin et al., 1994; Korshin et al., 1999; Dilling and Kaiser, 2002; Kalbitz et al., 2003).

Following this, when spectral values (of these specific wavelengths) of the water-soluble (both normal water soluble and hot water soluble) pools of soil C were studied, it clearly indicated a higher absorbance of the subsurface soil C in comparison to soils of surface layers (Fig. 1, 3). Likewise, higher absorbance of C pools was noted in soils collected from rice soil ecology compared to non-rice soil ecologies (Fig. 2, 4). It also specifies that soil of lower depths has greater aromaticity, higher humification, and a larger molecular size of organic matter compared to surface soil. It was observed that irrespective soil depths, soil collected from rice-rice cropping systems (rice ecology) had an organic matter with higher aromatic and humified characteristics than that of soil collected from vegetable-vegetable (non-rice ecology) cropping systems. Finally, it can be said that soil of lower depth (deep soil) can acts as a better niche for C sequestration compared to surface soil, while the soil of rice ecology can also act as a better sink for soil C sequestration compared to non-rice ecologies.

CONCLUSIONS:

In this study, water soluble C pools were assessed qualitatively using UV-Vis spectroscopy. The higher aromaticity, molecular weight, molecular size, and humification of organic matter were recorded in lower soil depth. The higher aromaticity and molecular weight of soil C were noted in rice soil ecology compared to non-rice soil ecology. Therefore, the potentiality of subsoil to act as a better sink for C sequestration was more than that of surface soil and rice soil acted as a better niche in soil C sequestration compared to non-rice soil.

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