Original Research Article

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 using UV-Vis spectroscopy. Soil sampling was done from three different long-term sites in eastern India. Absorbance characteristics of water-soluble C pools in different wavelengths (in UV- visible range) have the capacity to determine the C quality and stability in soils. Following this, when spectral values (of these specific wavelengths) of the 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. Similarly, soil pools collected from rice ecology showed higher absorbance than soils of non-rice ecology. Rice soil represented more aromatic and humified organic matter in comparison to non-rice soils, irrespective of soil depth. Therefore, this study conclusively can say that deep soil is a niche for C sequestration in rice ecology.

Keywords: Water-soluble 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 amends 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 conditions rice cultivation avails methane emission and rice cultivated soils are kenned to retain higher magnitudes of resilient C among all terrestrial ecosystems than drylands (Xie *et al*., 2007; IPCC, 2013). Rice cultivated soils have the highest C density and act as a paramount niche for C sequestration in upland soils, these soils recorded higher C density than that in upland soils (Xie *et al*., 2007).

In the assessment of different properties of dissolved organic carbon (DOC), a number of physical and chemical procedures are utilized, however, it comes to the assessment of C present in soil solution (Simonsson *et al.,* 2005). In this context, utilization of ultraviolet-visible (UV-Vis) absorption spectrophotometry was utilized to identify aromaticity, hydrophobic content, and biodegradability of soil organic carbon (SOC). These fractionations of SOC pools and spectroscopic analysis were done.

MATERIALS AND METHODS

Experiment location

Soil sampling was done at 3 varied locations of eastern India, viz. Gayespur Research farm in West Bengal, which is under Bidhan Chandra Krishi Viswavidyalaya (BCKV); Research Farm managed by Bihar Agricultural University, Sabour, Bihar and Central Farm at Bhubaneswar, Odisha which is managed by Orissa University of Agriculture and Technology (OUAT). All these research locations were a component of long-term field crop experiments. Within each location, sampling plots were selected under Paddy (Rice-Rice) as well as non-rice (wheat-fallow, plantation crops, and vegetable-vegetable) predicated on different cropping systems. Soil samples were taken only from those research sites having at least 10-15 years of sustainable continuity of the same cropping system to extract the signature trend of that cropping system and management practices on soil Carbon (Carillo *et al.*, 2012).

Soil Sampling

Entire soil sampling was taken in the fallow seasons of 2019-2020 *kharif* to prevent the impact of tillage as well as rain interruption. Within each location, soil samples were collected from rice and non-rice-based cropping systems. Again, under each cropping system, soils were collected from two sites. To compare qualitative and quantitative C dynamics of surface and below-ground deep soils, samples were collected from 0-20 cm as well as from 100-120 and 120-140 cm of each field replication. Therefore, the total number of soil samples for this study was 36 (3 locations x 2 cropping systems x 2 sites x 3 depth). Further, composite soil sampling was done for each depth of each site. Spade was used for soil sampling. To exactly determine the sampling location, a hand-held GPS receiver (Garmin, Olathe, KS, USA) was used.

Spectroscopic analysis dissolved C pools of soil

Spectroscopy has been identified as a very potent tool to study and characterize the structure of intricate organic compounds (Wang *et al.*, 2013). Generally, UV-Vis spectroscopy is utilized to determine the characteristics of aliphatic and aromatic compounds present in DOC (Li *et al*., 2010). It also determines the hydrophobic content and biodegradability of DOC. In this study, in order to determine the variation of the functional group according to transmute in-depth and crop ecology the absorbance at nine (9) discrete wavelengths as well as perpetual spectra within the range 250 nm and 500 nm has been taken.

Table 1. The list of nine discrete wavelengths along with their determining 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

A study of water-soluble C and density-fractionated soil pools using UV-VIS spectroscopy indicated a higher residence time of C in the subsoil in comparison to surface soil layers. Besides, the soils of rice ecology also indicated recalcitrant characteristics in comparison to non-rice soil counterparts. UV-Vis spectroscopy was used in the present study.

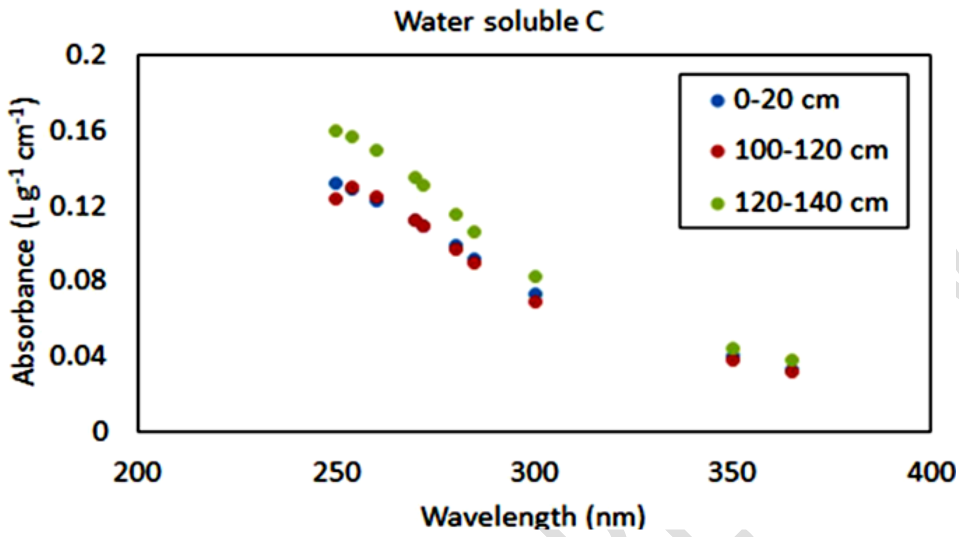

Fig. 1. The absorbance of water-soluble C pool in different soil depths in various discrete points

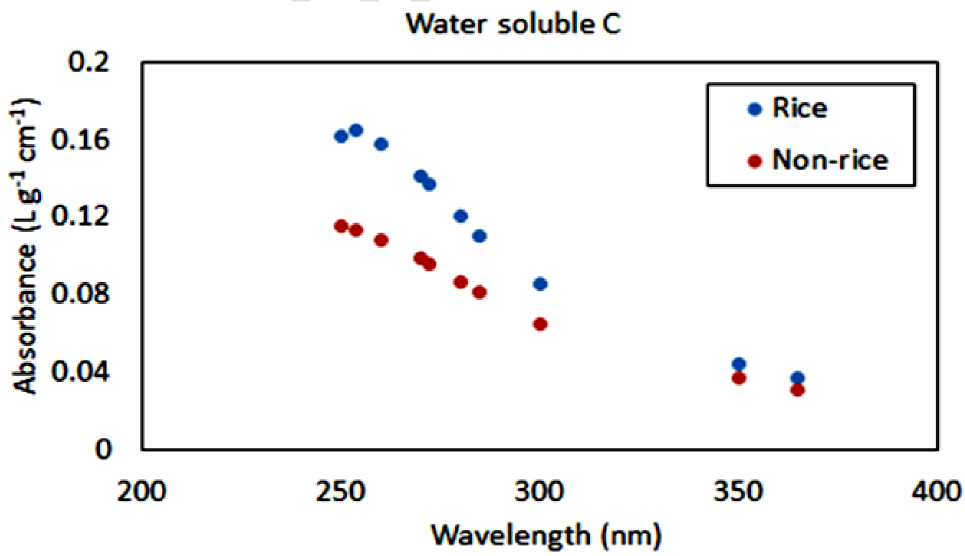

Fig. 2. The absorbance of water-soluble C pool in different soil ecologies in various discrete points

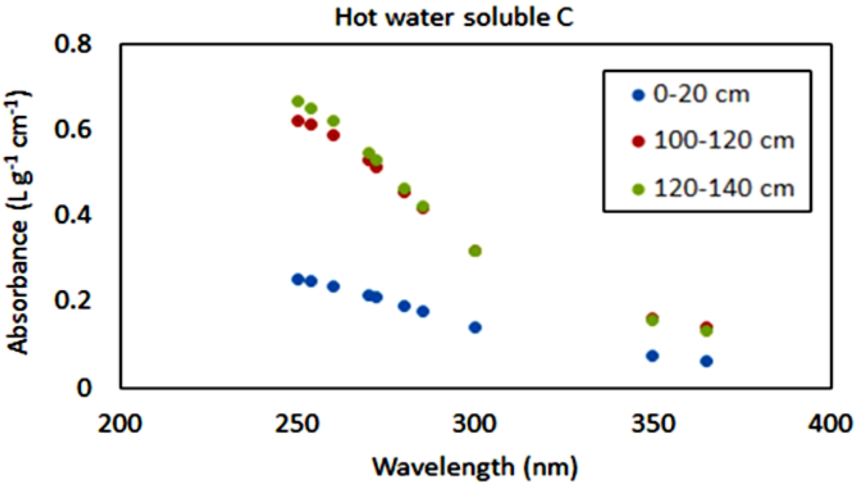

Fig. 3. The absorbance of hot water-soluble C pool in different soil depths in various discrete points

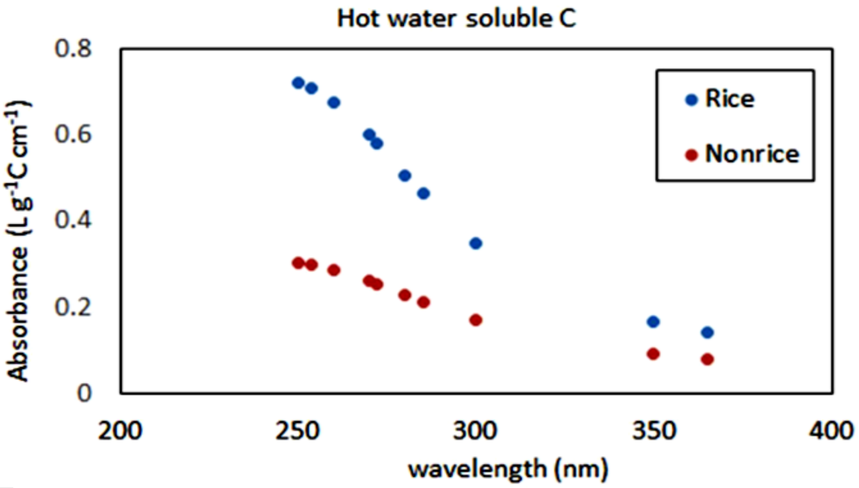

Fig. 4. The absorbance of hot water-soluble C pool in different soil ecologies in various discrete points

Absorbance characteristics of water-soluble C pools in different wavelengths (in UV- visible range) have the capacity to determine the C quality and stability in soils. For example, higher absorbance in 250, 254, 272, and 365 nm is indicative of higher aromaticity and greater molecular weight of soil organic matter (Hur and Schlautman, 2003). On the other hand, greater absorbance in 260 and 280 nm means more hydrophobic C and greater humification. Absorbance at 280 and 350 nm is indicative of the molecular size of the organic compounds. 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). Similarly, soil pools collected from rice ecology showed higher absorbance than soils of non-rice ecologies (Fig. 2, 4). It meant higher aromaticity, greater humification, and bigger molecular size of organic matter in subsoil layers. Rice soil represented more aromatic and humified organic matter in comparison to non-rice soils, irrespective of soil depth. Therefore, this study conclusively can say that deep soil is a niche for C sequestration while rice ecology is a niche for soil C sequestration compared to upland non-rice ecologies.

CONCLUSIONS:

This study used UV-Vis spectroscopy for the qualitative assessment of soil C pools. Spectral analysis of the water-soluble C pools indicated increased aromaticity, molecular weight, molecular size, and humification of organic matter with an increase in soil depth. The Carbon under rice soil also showed higher aromatic character and molecular weight than the non-rice soil. Therefore, it can be concluded that the superiority of deep subsoil for C sink was more than that of surface soil and the potential of rice soil for soil C sequestration was more compared to upland non-rice soil.

REFERENCES:

Abbt-Braun, G., & Frimmel, F. H. (1999). Basic characterization of Norwegian NOM samples—similarities and differences. *Environment International*, *25*(2-3), 161-180.

Artinger, R., Buckau, G., Geyer, S., Fritz, P., Wolf, M., & Kim, J. I. (2000). Characterization of groundwater humic substances: influence of sedimentary organic carbon. Applied Geochemistry, 15(1), 97-116.

Bhattacharyya, T., Pal, D.K., Ray, S.K., Chandan, P., Mandal, C., Telpande, B., Deshmukh, A.S. and Tiwary, P. 2013. Simulating change in soil organic carbon in two long fertilizer experiments in India: with the Roth C model. *Climate Change and Environmental Sustainability*, **2**: 107-117.

Brahim, N., Blavet, D., Gallali, T. and Bernoux, M. 2011 Application of structural equation modeling for assessing relationships between organic carbon and soil properties in semiarid Mediterranean region. *Int J Environ Sci Tech*, **8(2):**305–320.

Carillo, A., Sannino, G., Artale, V., Ruti, P.M., Calmanti, S. and Dell Aquila, A. 2012. Steric sea level rise over the Mediterranean Sea: present climate and scenario simulations. Climate dynamics, **39**: 2167-2184.

Chin, S. F., Storkson, J. M., Albright, K. J., Cook, M. E., & Pariza, M. W. (1994). Conjugated linoleic acid is a growth factor for rats as shown by enhanced weight gain and improved feed efficiency. *The Journal of nutrition*, *124*(12), 2344-2349.

Dilling, J., & Kaiser, K. (2002). Estimation of the hydrophobic fraction of dissolved organic matter in water samples using UV photometry. *Water Research*, *36*(20), 5037-5044.

Hur, J., & Schlautman, M. A. (2003). Molecular weight fractionation of humic substances by adsorption onto minerals. *Journal of colloid and interface science*, *264*(2), 313-321.

IPCC. 2013. Climate Change 2013. In: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change In: Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia Y., Bex, V., Midgley P.M. (Eds.). Cambridge University Press, Cambridge, United Kingdom and New York.

Kalbitz, K., Geyer, S., & Geyer, W. (2000). A comparative characterization of dissolved organic matter by means of original aqueous samples and isolated humic substances. *Chemosphere*, *40*(12), 1305-1312.

Kalbitz, K., Schmerwitz, J., Schwesig, D., & Matzner, E. (2003). Biodegradation of soil-deriveddissolved organic matter as related to its properties. *Geoderma*, *113*(3-4), 273-291.

Kalbitz, K., Schwesig, D., Schmerwitz, J., Kaiser, K., Haumaier, L., Glaser, B., ... & Leinweber, P. (2003). Changes in properties of soil-derived dissolved organic matter induced bybiodegradation. *Soil Biology and Biochemistry*, *35*(8), 1129-1142.

Kalbitz, K., Solinger, S., Park, J. H., Michalzik, B., & Matzner, E. (2000). Controls on the dynamics of dissolved organic matter in soils: a review. *Soil Science*, *165*(4), 277-304.

Korshin, G. V., Kumke, M. U., Li, C. W., & Frimmel, F. H. (1999). Influence of chlorination on chromophores and fluorophores in humic substances. *Environmental Science & Technology*, *33*(8), 1207-1212.

Lal, R. 2004. Soil carbon sequestration impacts on global climate change and food security. Science, **304**: 1623-1627.

Li, M.X., He, X.S. and Liu, J. 2010. Study on the characteristic UV absorption parameters of dissolved organic matter extracted from chicken manure during composting. Spectroscopy and Spectral Analysis, **30**: 3081-3085.

Peuravuori, J., & Pihlaja, K. (1997). Molecular size distribution and spectroscopic properties ofaquatic humic substances. *Analytica Chimica Acta*, *337*(2), 133-149.

Simonsson, M., Kaiser, K., Andreux, F. and Ranger, J. 2005. Estimating nitrate, dissolved organic carbon and DOC fractions in forest floor leachates using ultraviolet absorbance spectra and multivariate analysis. Geoderma, **124:** 157-168.

Traina, S. J., Novak, J., & Smeck, N. E. (1990). An ultraviolet absorbance method of estimating the percent aromatic carbon content of humic acids. *Journal of environmental quality*, *19*(1), 151-153.

Wang, K., Li, W., Gong, X., Li, Y., Wu, C. and Ren, N. 2013. Spectral study of dissolved organic matter in biosolid during the composting process using inorganic bulking agent: UV–vis, GPC, FTIR and EEM. *International Biodeterioration & Biodegradation*, *85*: 617-623.

Xie, Z.B., Zhu, J.G., Liu, G., Cadisch, G., Hasegawa, T., Chen, C. M., Sun, H. F., Tang, H. Y. and Zeng, Q. 2007. Soil organic carbon stocks in China and changes from 1980s to 2000s. Global Change Biology, **13:** 1989-2007.

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