Available online at: www.mbai.org.in
doi:10.6024/jmbai.2021.63.2.2284-19

Capture and storage of Carbon in seagrass beds of a vulnerable species *Halophila beccarii* (Asch.) at the Kadalundi Estuary, Kerala, India

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Received: 07 Apr 2021 Accepted: 17 Sep 2021 Published: 10 Oct 2021

Short communication

Abstract

Seagrass habitats are efficient carbon sink that can bury and store organic carbon for a long time. We report here the capture of dissolved CO_2 by the ocean-turf grass, *Halophila beccarii* and its storage as carbon stock in the sediments extending an area of two hectares in the mudflats of Kadalundi Estuary. The organic carbon content in the seagrass sediment showed gradual increase from 0.473% during January to 0.824% during March. Organic carbon content in the sediment within the *Halophila* bed was 110- 134% higher than that of outside the seagrass bed. The three months observation, though a short term study revealed that the mean values of blue carbon stock of *Halophila* beds of Kadalundi Estaury were at 2.655±0.34 Mg C/ha. The capture potential of dissolved CO_2 by the seagrass, unravelled through an experiment involving intact plants showed that the *Halophila* plants could utilize 21.4%–25.7% of dissolved CO_2 in light within 2 hours.

Keywords: *Blue carbon stock, dry bulk density, soil organic carbon, ocean-turf grass, seagrass meadows*

Introduction

The term Blue Carbon refers to the carbon stored in sediments from coastal ecosystems such as seagrass meadows, mangrove forests and salt marshes. Seagrass meadows though occupy only below 0.2% area of the world's oceans, are considered one of the major blue carbon sinks that contribute indirectly to climate change mitigation as they are known to capture and bury enormous quantities of carbon annually (Duarte *et al*., 2013; Kaladharan *et al*., 2020). Seagrass species and distribution in the tropics vary considerably in size, root- shoot ratio, rate of primary production and carbon capture rates (Duarte *et al*., 1998; Duarte and Chiscano, 1999; Lavery *et al*., 2013). Carbon stocks and accumulation rates of five seagrass species studied from the coast of Saudi Arabia indicate significant variation among the species (Serrano *et al*., 2018).

Although blue carbon stocks of seagrass meadows are known from a few regions such as Abu Dhabi (Campbell *et al*., 2015), Western Indian Ocean (Gullstorm *et al*., 2018), East and Southeast Asian seagrass meadows (Miyajima *et al*., 2015), Saudi Arabia (Serrano *et al*., 2018), Chilka Lake along Odisha Coast (Banerjee *et al*., 2018) and Gulf of Mannar- Palk Bay (Kaladharan *et al*., 2020) there has been a paucity of data from other parts to improve the global estimates. An increase in the coastal settlements and coastal developments threaten seagrass habitats globally and the shrinking of seagrass meadows is taking place very rapidly (Waycott *et al.*, 2009; Fourqurean *et al.*, 2012; Kaladharan and Anasukoya, 2019). Here we attempt to bring out the blue carbon stock of monospecific seagrass bed of a vulnerable seagrass *Halophila beccarii* from Kadalundi Estuary, Kerala.

Material and methods

Study site

Kadalundi Estuary is a moderately large estuarine system with many mangrove (*Avicennia, Rhizophora* and *Sonneratia* spp.) patches around it. Extensive seagrass bed covering an area of more than 2 hectares (11° 08' N; 75° 50'E) of *Halophila beccarii* (Asch.) locally known as ocean-turfgrass was found growing in the mudflats close to barmouth and the Kadalundi Community Reserve area. The substratum was coastal alluvium dominated by clay. During the low tide, the seagrass bed remained exposed (Fig. 1). This mangrove cum seagrass area is managed by the Kadalundy Community Reserve and Forest Department, Government of Kerala. This protected area attracts a large number of migratory birds for foraging and nesting.

Fig. 1. Distant view of seagrass bed in Kadalundi Estuary

Blue carbon assessment

Blue carbon stock of the *Halophila* beds of Kadalundi Estuary was computed according to the procedure mentioned in Jones *et al.* (2005) from the soil carbon density of 27sediment core samples taken from three sites within the mudflat during January – March 2021. Sediment samples up to 30 cm depth in triplicate were taken from each site using a locally fabricated sediment corer (Kaladharan *et al.*, 2020) to get three cores of 10 cm interval (Core A, 0-10 cm, Core B, 10-20 cm and Core C, 20-30 cm) from each site. After determining the dry weight and dry bulk density of the cores, organic carbon content (C_{org} %) in the sediment cores after removing any shells, plant parts etc if any were determined according to the standard method of Walkley and Black (1934).

Fixation of dissolved CO_2 by seagrass

To estimate the rate of utilization of dissolved CO_2 by the canopy, intact plants of *Halophila beccarii* (Fig. 2) were removed from the mud, washed thoroughly with the seawater to remove any dirt, adhering sediment traces and attached flora and fauna if any. The drained weight of these plantlets were noted and incubated in triplicates in clear bottles with three levels (ambient, x and 2x) of dissolved CO_2 (Kaladharan *et al.*, 2019) fitted tightly with rubber lids and the top of the bottles were wrapped with aluminium caps to prevent the escape of CO_2 during the incubation in light for two hours. Similar set up without plants in triplicates were served as control. Determined the CO_2 concentration in the experimental and control bottles before and after the incubation using the titration method as described by Dye (1958).

Fig. 2. Close up view of seagrass *H. beccarii*

Results and discussion

Sedimentary carbon content

Seagrass bed in Kadalundi Estuary is so dynamic that the organic carbon content in the seagrass sediment showed gradual increase from January to March (Table 1) ranging from 0.473% to 0.824%. Organic carbon content in the sediment within the *Halaophila* bed was 110% higher than that of outside the seagrass bed during January which registered an increase gradually to 128% during February and 134% during March (Table 1). The organic carbon content in seagrass habitats were reported higher in various sediment profiles than in non-seagrass habitats (Gullstrom *et al.*, 2018). Our observation from the *Halophila* beds also reiterates the significant role of seagrass vegetation towards the blue carbon stock enhancement in the mudflats of Kadalundi Estuary.

Table 1. Soil Organic carbon content (C org. %) of *Halophila* beds of Kadalundi Estuary

Month	Seagrass bed	No Seagrass	% increase
January	0.522±0.05	0.473±0.04	110
February	0.765±0.06	0.599±0.05	128
March	0.824±0.14	0.617±0.07	134

Blue carbon stock of Kadalundi seagrass bed

Although the soil organic carbon content in the top core (0-10 cm) of the *Halophila* bed was higher than the subsurface cores (10-20 cm and 20-30 cm layers), the dry bulk densities were higher in the subsurface cores. The blue carbon buried in the *Halophila* beds at Kadalundi Estuary registered the highest during February (3.059±0.41 M g C/ha) and the lowest levels (2.2307±0.36 M g C/ha) during March (Table 2). From the three months observation, it is observed that the mean values of blue carbon stock of *Halophila* beds of Kadalundi Estaury was at 2.655±0.34 M g C/ha. Serrano *et al.* (2018) while comparing the sedimentary carbon accumulation rates of different seagrass species have also observed though lower dry bulk density in *Thalassia hemprichii* habitats, the sedimentary organic carbon content was higher than that of the other four species.

Although the guidelines for assessing blue carbon deposit and carbon sequestration from seagrass meadows (Jones *et al.*, 2005) recommend a depth of one meter, we did limit with only 30 m depth as the sediment corer was operated manually and beyond 30 m, it was difficult to draw sediment cores intact without any mechanical support in the field. Bedulli *et al.* (2020) did assess the organic carbon stock of seagrass medows with 50 cm thick sediment and reports that monospecific meadows of *Halophila* spp recorded the lowest carbon stock of 12 M g C/ha, while that of *Posidonia* spp and *Amphibolis* spp showed the highest levels of 63 M g C/ha.

Table 2. Blue carbon stock of *Halophila* beds of Kadalundi Estuary

Month	Blue Carbon Stock (M g C/ha)
January	2.674831±0.34
February	3.05938±0.41
March	2.230743±0.36
Mean	2.654985± 0.34

Capture potential of dissolved CO_2

Intact seagrass plants were found capable of capturing dissolved CO_2 which was spiked to the ambient level in seawater used for the incubation experiments (Table 3). When 7 ppm of CO_2 was added to the ambient seawater, the *Halophila* plants could capture 1.5 ppm CO_2 (21.4%) at light within 2 hours, while the control set (without *Halophila* plants) fixed just 0.1 ppm only (1.43%). Similarly, when the dissolved CO_2 levels were doubled (14 ppm), it resulted in fixation of 3.6 ppm (25.7%) by the plants and 0.4 ppm (2.86%) in the control set of the experiment (Table 3). Photosynthetic activity buffers ocean acidification by seagrasses (Hendirks *et al.*, 2014) and by seaweeds (Kaladharan *et al.*, 2019). Our present experiment also confirmed the efficiency of seagrass canopy in capturing and sequestering dissolved CO_2 by *Halophila beccarii* while actively taking part in photosynthesis at a shorter duration which can help mitigate ocean acidification. Our quantitative observation on the blue carbon stock from the Kadalundi Estuary is the first report on this seagrass from India and a significant contribution to the existing global database.

Table 3. Rate of dissolved carbon (ppm) captured by *Halophila beccarii*

Initial level of CO_2	Final levels of CO_2 With *Halophila* light	after 2 hour incubation in Without *Halophila*
0	0	0
7	1.5 (21.4%)	0.1 (1.43%)
14	3.6 (25.7%)	0.4 (2.86%)

Acknowledgements

The authors thank the Director, ICAR- CMFRI for the encouragements and facilities received during the investigation and the Indian Council of Agricultural Research, New Delhi for the financial support.

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