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Organic carbon storage in sediments of seagrass habitats in the lagoons of Lakshadweep Archipelago, west coast of India

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Original Article

Abstract

Vegetated habitats like mangroves, seagrasses and saltmarshes capture and store carbon and act as carbon sinks. The carbon captured and stored in these habitats, especially in the below-ground sediments, is called blue carbon. We report the blue carbon storage potential of seagrass habitats from the lagoons of Agathi, Bangaram, Kavaratti, Kalpitti, Thinnakara and Parli Islands of the U.T. of Lakshadweep. Sediment core samples were collected in triplicate from 30 cm deep from six stations located in the lagoons and estimated the organic carbon content in the sediment samples. The mean C_{org} ranged from 0.1863 (Bangaram) to 0.3453% (Thinnakara); while the dry bulk density was 0.9115 (Kalpitti) to 1.1174 g/cm^3 (Kavarathi). Of the six Islands studied for blue carbon storage, the Thinnakara lagoon registered the highest level of 0.9795 mgC/ha and the Bangarum lagoon showed the lowest rate of 0.3796 mgC/ha. Very low organic carbon stock in these lagoons indicated an urgent need for restoring and reviving the seagrass meadows, which are shrinking rapidly.

***Keywords**: Blue carbon stock, carbon sequestration, dry bulk density, island ecosystem, organic carbon*

Introduction

Seagrass habitats are the most effective natural ecosystems that can capture and store large quantities of carbon from the atmosphere (Smith, 1981; Duarte *et al*., 2005; Kaladharan *et al*., 2020). Of the 72 species of seagrasses reported so far across the world (Short *et al*., 2007; Unsworth and Unsworth, 2013), India has 16 species and 14 of them occur in the Gulf of Mannar and Palk Bay; seven species in Lakshadweep and nine in Andaman and Nicobar archipelagos (Thangaradjou and Bhatt, 2018). Seagrass meadows are the major primary producers in Lakshadweep atolls (Qasim and Bhattathiri, 1971; Nair and Pillai, 1972; Kaladharan *et al*., 1998) and their distribution sometimes decides the trophic levels (Kaladharan and David Raj, 1989). Nobi *et al.* (2011) studied the distribution and biology of seagrasses in the Lakshadweep Islands. Seagrass beds in the lagoons provide critical habitats for more than 100 species belonging to finfish, turtles, seahorses, dugongs, shrimps, crabs, sea cucumbers, sea urchins, starfish, gastropods, bivalves, ascidians, sponges, anthozoans, marine algae and phytoplankton (Kaladharan *et al*., 2018).

Growing coastal populations and increasing coastal developments threaten the seagrass habitats globally and the loss of seagrass habitats are estimated to be 29% (Waycott *et al*., 2009; Duarte *et al*., 2010; Unsworth and Unsworth, 2013). Shrinking seagrass beds in Lakshadweep Islands (Kaladharan and Anasukoya, 2019) is believed to be exacerbated due to the turtle herbivory (Kaladharan *et al*., 2013), smothering by plastic debris (Kaladharan and Anasukoya, 2020), besides anthropogenic interferences and climate change.

It is estimated that nearly one-third of all CO_2 emissions for the past 200 years have been absorbed by the oceans (Sabine *et al*., 2004). It is predicted that the CO_2 levels would exceed 1000 ppm and the average pH of the oceans could fall by 0.5 units (equivalent to a threefold increase in the concentration of hydrogen ions) by the year 2100 if global emissions of CO_2 continue to rise on current trends (The Royal Society, 2005). Seagrass meadows rank among the most significant organic carbon (C_{org}) sinks on earth (Mazarrasa *et al*., 2021; Serrano *et al*., 2018; 2019). The carbon storage potential of seagrass meadows from Indian waters is known from the Gulf of Mannar and Palk Bay (Kaladharan *et al.*, 2020), Chilika and Pulicat Lakes (Kaladharan *et al.*, 2021a) along the east coast and from Kadalundi Estuary (Kaladharan *et al.*, 2021b) along the west coast. This communication is intended to bring out the blue carbon storage potential of seagrass habitats from the lagoons of Agathi, Bangaram, Kavaratti, Kalpitti, Thinnakara and Parli Islands of U.T. of Lakshadweep for the first time.

Material and methods

Study sites

The islands, from where the sediment samples were collected, their geolocations and the date of sampling are presented in Table 1. Seagrass observation and collection of sediment samples from the lagoons were carried out during the low tide hours (Indian Tide Table, 2021). Seagrass species found in the lagoon of the islands studied during February 2021 comprised only three species such as *Halodule uninervis, Halophila ovalis* and *Cymodocea serrulata*. Seagrass beds of all the six islands had the same species but in varying sizes and densities.

Blue carbon stock assessment

Blue carbon stocks of the seagrass meadows were computed according to the procedure mentioned in Jones *et al.* (2005) from the soil carbon density of sediment core samples taken from different locations within the lagoons of six islands (Table 1). Sediment samples up to 30 cm in depth in triplicate were taken from each site using a locally fabricated sediment corer (Kaladharan *et al.*, 2020) to get the cores of 10 cm intervals. Hence from each site 9 sediment cores (three of Core A, 0-10 cm; three Cores of B, 10-20 cm; three Cores of C, 20-30 cm) were obtained. After determining the dry weight and dry bulk density of the cores, the organic carbon content (C_{org} %) in the sediment cores was determined according to the standard method of Walkley and Black (1934).

Results and discussion

Seagrass ecosystems are one of the most productive ecosystems in the world and have higher growth rates, producing organic matter of about 300-600 g dry weight/m^2/year (Hartog, 1970; Thayer *et al.,* 1975). It was estimated that an impairment of up to 50% on the NPP rates of seagrass plants was attributed to the prolonged exposure (emersion) of the seagrass meadows to bright sunshine in the intertidal areas during the ebb tide when compared to those seagrass plants growing in submerged habitats within the lagoon (Kaladharan *et al.*, 1998). The present observation revealed that the seagrass habitats of the Islands we studied were found degraded with rudimentary stock mostly grazed shoots and the flora is composed of unispecific *Halophila ovalis* or *Halodule uninervis* in most of the lagoons studied. These lagoons were once densely populated with *Thalassia hemprichii*, *Syringodium isoetifolium* and *Cymodocea serrulata* (Kaladharan *et al.*, 1998; Kaladharan *et al.*, 2013) were found absent in most of the lagoons during our recent study.

Sediments up to 30 cm from the surface of seagrass habitats of Agathi lagoon showed C_{org} values at a minimum of 0.086 % to a maximum of 0.346% and the dry bulk density ranging from 0.828-1.251 g/cm^3, registering mean values of 0.2137% and 1.0136 g/cm^3, respectively. The mean values of C_{org} levels in the seagrass sediment were highest in Thinnakara (0.3453%) and the lowest in Bangaram (0.1863%), while the dry bulk density registered the highest value (1.1174 g/cm^3) from Kavarathi and the lowest value 0.9115 g/cm^3 from Kalpitti (Table 2).

In Agathi and Kavarathi atolls, although the dry bulk densities of seagrass sediment in most of the study sites were higher in the second core (10-20 cm depth), the C_{org} content was higher in the top cores (0-10 cm depth). Of the six Islands studied for blue carbon storage in their seagrass habitats, the Thinnakara lagoon registered the highest rate of 0.9795 mgC/ha and the Bangarum lagoon showed the lowest rate of 0.3796 mg C/ha (Table 3).

Table 1. GPS coordinates and lagoon area of islands studied among the Lakshadweep group of Islands.

No.	Name of atoll	GPS coordinates	Land area (sq. km)*	Lagoon (sq. km)*	Date of sampling
1	Agathi	Lat.10° 85' N Long.72° 18' E	3.84	8.8	24-26th Feb. 2021
2	Bangaram	Lat.10° 93' N Long.72° 29' E	0.58	7.2	27-2-2021
3	Kavaratti	Lat.10° 56' N Long.72° 62' E	4.22	6.75	22-23rd Feb. 2021
4	Kalpitti	Lat.10° 81' N Long.76° 17' E	0.07	2.1	25-2-2021
5	Parli	Lat.10° 95' N Long.72° 33' E	0.46	1.75	27-2-2021
6	Thinnakara	Lat.10° 94' N Long.72° 31' E	0.42	1.25	27-2-2021

*Basic Statistics (2014).

Table 2. Organic carbon content (C_{org} %) and dry bulk density in the seagrass sediments collected from six islands (Mean ± SD and in parenthesis the minimum-maximum).

Islands	C_{org} (%)	Bulk density (g/cm³)	n
Agathi	0.2137± 0.084 (0.086-0.346)	1.0136± 0.161 (0.828-1.251)	21
Bangarum	0.1863± 0.091 (0.087- 0.312)	1.0110± 0.078 (0.883- 1.078)	21
Kavarathi	0.1937± 0.073 (0.087- 0.424)	1.1174± 0.219 (0.853- 1.470)	18
Kalpitti	0.3162± 0.062 (0.230- 0.404)	0.9115± 0.109 (0.773- 1.113)	21
Parli	0.2236± 0.125 (0.029- 0.316)	1.0170± 0.101 (0.879- 1.105)	12
Thinnakara	0.3453± 0.164 (0.144- 0.546)	0.9480± 0.205 (0.658- 1.099)	15

Organic carbon storage by seagrass beds exhibits considerable inter habitat variability (Bedulli *et al*., 2020; Mazarrasa *et al*., 2021). Potouroglou *et al.* (2021) have found that the 50cm thick sediment carbon stocks in the intertidal seagrass meadows in Scotland retained 20% more organic carbon than the unvegetated plots in the same meadows. Mazarrasa *et al.* (2021) found that the soil C_{org} stocks were similar across bioregions and geomorphic settings, but meadows formed by large species (i.e. *Amphibolis* spp. and *Posidonia* spp.) showed higher stocks (24–29 mgC /ha) than those formed by smaller species such as *Halodule, Halophila, Ruppia, Zostera, Cymodocea* and *Syringodium* (12–21 mgC/ha). Our results on carbon stock stored in seagrass sediments from the six lagoons are considerably very low compared to that obtained from Palk Bay (3.881M g C/ha, Kaladharan *et al*., 2020) and from Chilika Lake (2.0183M g C/ha (Kaladharan *et al*., 2021a) indicating the sparse distribution of smaller species that too severely grazed and the absence of dense seagrass habitats.

When the lagoons of Agathi, Chetlat, Kavaratti and Kiltan Islands were monitored from 2011 to 2015 period indicated a gradual but steady shrinking of seagrass meadows and the percentage reduction in density of seagrass meadows was estimated at 88.5% in Agathi, 88.7% in Chetlat, 88.4% in Kavarathi and 81.3% in Kiltan. Wet biomass of parts below the sediment (rhizomes and roots of seagrass) were always higher than the epigeal parts comprising leaves, stem and bracts as evidenced by very high root: shoot ratios ranging from 2.3–12.6 (Kaladharan *et al*., 2013). Scientific evidence obtained from the Virginia coast indicates that restoration of seagrass habitats (Orth *et al*., 2020) can revive the lost biodiversity of faunal assemblages and sequester substantial stocks of carbon and nitrogen.

Table 3. Blue carbon (mean ± SD) stored (carbon stock) in the seagrass habitats of six lagoons

Islands	Blue carbon (mgC/ha)	Range (mgC/ha)	n
Agathi	0.4189± 0.057	0.1881-0.5452	7
Bangarum	0.3797± 0.063	0.1055-0.4711	7
Kavarathi	0.5527± 0.026	0.1354-0.6248	6
Kalpitti	0.8797± 0.082	0.4183-0.9458	7
Parli	0.6021± 0.109	0.0932- 0.8125	4
Thinnakara	0.9795± 0.147	0.5583 -1.4354	5

As seagrass meadows are well known for their ecosystem services, even a slight reduction in seagrass cover is sufficient enough to cause serious ecological and economic consequences. The blue carbon stock assessment from seagrass habitats of six Islands of the Lakshadweep sea indicates an urgent need for restoring and reviving the seagrass meadows which are degrading rapidly.

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