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Blue Carbon Stock of Seagrass Meadows of Chilika and Pulicat Lakes along the Eastern Coast of India

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Abstract

Blue carbon stock of seagrass meadows of Chilika (Odisha) and Pulicat (Tamil Nadu) Lakes located along the eastern coast of India is estimated from the data collected on soil organic carbon content (C org) of monospecific or multispecific seagrass habitats up to 30 cm depth sampled during 2018-2019 period. Chilika Lake harbours five seagrass species in addition to the invasive aquatic weed *Potamogeton pectinatus*. Seagrass habitats in the Pulicat Lake are formed of monospecifc species of seagrasses in association with considerable quantities of red and green seaweed resources. The blue carbon stock of seagrass habitats up to a depth of 30 cm of Chilika Lake was estimated to 2.018±0.673 M gC ha^{-1} while that of Pulicat Lake was determined to 0.998± 0.418 M gC ha^{-1}. Our results do contribute to the global data sets on blue carbon stored in seagrass habitats and its significance on carbon trading.

Keywords: Carbon sink, Carbon sequestration, Organic carbon, Dry bulk density, Carbon Trading

Introduction

Seagrass meadows are ocean's greatest carbon sink which are highly productive and dynamic. These seagrass meadows form the feeding and breeding grounds for dugongs, green turtles, many finfish and shellfish resources, invertebrates of commercial and ecological importance. In India seagrass meadows are reported from Gulf of Mannar and Palk Bay along the Tamil Nadu coast, Gulf of Kachchh in Gujarat coast and the shallow bays in Andaman – Nicobar and Lakshadweep Archipelagos (Jagtap et al., 1991; Kaladharan et al., 1998; Kannan et al., 1999) besides in the Chilika Lake (Priyadarsini et al., 2014; Bhatta & Patra, 2018) and in the Pulicat Lake (Kaladharan et al., 2019). A total area of 516.59 km^2 has been estimated as seagrass cover in India using geospatial tools (Geevarghese et al., 2017) without including seagrass beds in many atolls of Lakshadweep and Pulicat and Ashatamudi Lakes. Chilika Lake is the largest brackish water lagoon in Asia with an area ranging from 900- 1165 km^2 which is fed by 52 rivers and rivulets (Geevarghese et al., 2017). Pulicat Lake is the second largest brackish water lake in India with an area of approximately 481 km^2 running parallel to the Bay of Bengal adjoining Tamil Nadu and Andhra Pradesh (Kaladharan et al., 2019).

Coastal ecosystem consisting of saltmarshes, mangroves and seagrass meadows are considered as blue carbon ecosystems and are increasingly being recognized for their significant role in carbon sequestration and thus to climate change mitigation globally. The IPCC (2003) recommended that countries should aspire for Tier 3 system for the measurement of key carbon stocks of ecosystems. Tier 3 system underlines the need for repeated estimates of change or flux of carbon through direct field measurements or by modelling. Information on blue carbon stock of seagrass meadows are available from the Red Sea seagrasses (Serrano et al., 2018), Western Australian seagrass meadows (Serrano et al., 2019), *Zostera marina* beds in the coastal bays of Virginia (Greiner et al., 2013) as well as Gulf of Mannar and Palk Bay from the Indian subcontinent (Kaladharan et al., 2020). Yet there exists still a wide gap in global datasets on blue carbon stock to be filled. We present here the firsthand report on the organic carbon content and blue carbon stored in the sediments of seagrass meadows of Chilika Lake and Pulicat Lakes.

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Material and Methods

From the Chilika Lake (Fig. 1) field data and samples were collected from 10 locations positioned between latitude 19º 28' -19º 54' N and longitude 85º 05'- 85º 38' E stretching over Puri, Khurda and Ganjam districts of Odisha during November 2019. From the Pulicat Lake (Fig. 2) field observations on major seagrass beds and sample collection were attempted from 23 locations situated between 13º 22' to13º 43' N latitude and 80º 03' to 80º 19' E longitude during March, June and October 2018. Besides seawater and sediment collection from these locations, seagrass species, density, wet biomass and associated organisms were also studied using a 1 sq.m quadrat.

Blue carbon stocks of 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 10 sites within the southern and central parts of Chilika Lake and from 23 sites within the Pulicat Lake (Fig. 1 and 2). 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 the cores of 10 cm interval. Hence from each site 9 sediment cores (3 numbers of Core A, 0-10 cm, 3 Cores of B, 10-20 cm and 3 Cores of C, 20-30 cm) were obtained. After determining the dry weight and dry bulk density of the cores, organic carbon content (C_{org}) in the sediment cores were determined according to the chromic acid wet oxidation method (Walkley & Black, 1934).

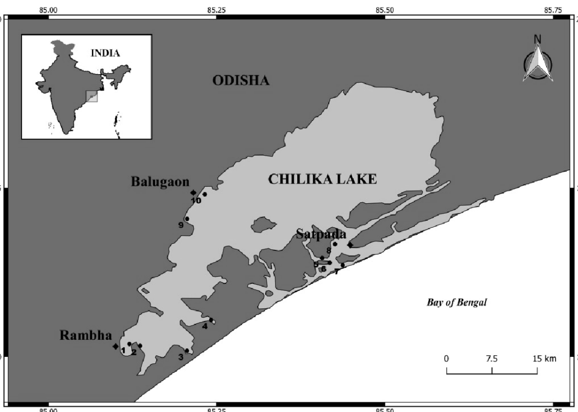

Fig. 1. Location map of sampling sites in Chilika Lake

Results and Discussion

The organic carbon content (C_{org}) in the sediments from seagrass habitats of Chilika Lake showed a

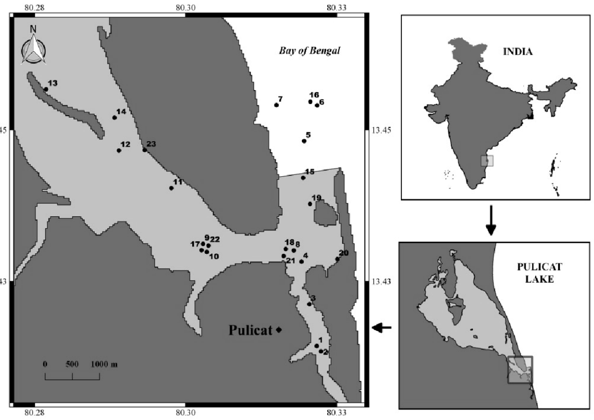

Fig. 2. Location map of sampling sites in Pulicat Lake

mean of 0.395 ± 0.21% ranging from 0.058% to 0.952%. The C_{org} content of subsurface layers was higher than that of the surface (0-10 cm) cores. The dry bulk density was also higher in subsurface cores than that of the surface layers in all the study sites except at Rajahams (Stn. 7). The soil carbon density showed highest levels at Rajahams area and the lowest at Satapada (Stn. 8, Fig.1). In the Pulicat Lake C org content registered a mean value of 0.473±0.243% ranging from 0.026 – 0.929%. Similar to Chilika Lake, the subsurface cores (10-20 cm and 20-30 cm) of sediment from ulicat Lake registered higher values of C_{org} than in surface cores (0-10 cm; Table 1).

Chilika Lake harbours five seagrass species namely *Halodule uninervis*, *Halodule pinifolia*, *Halophila ovalis*, *Halophila ovata* and *Halophila beccarii* in addition to the invasive aquatic weed *Potamogeton pectinatus* (Sarma et al., 1981; Priyadarsini et al., 2014; Banerjee et al., 2018). While in the Pulicat Lake seagrass habitats of monospecifc species such as *Halophila stipulacea, H. beccarii, Halophila ovalis* and *Halodule pinifolia* forming dense meadows in addition to considerable quantities of seaweed resources like *Hypnea*, *Gracilaria*, *Ulva* and *Enteromorpha* spp. (Kaladharan et al., 2019).

The blue carbon stock of seagrass habitats of Chilika Lake upto a depth of 30 cm was estimated to 2.018 ±0.673M gC ha^{-1} while that of Pulicat Lake was determined to 0.998± 0.418 M gC ha^{-1} (Table 1). Significant variability in storage of organic carbon in different seagrass habitats has been observed by Bedulli et al. (2020). The observed increase in the blue carbon stock in the sediments of Chilika Lake than that of the Pulicat Lake may be due to the variation in soil texture, composition although the density of

Table 1. Sediment, organic carbon content and vegetation characteristics of some seagrass habitats of Chilika and Pulicat Lakes.

Parameters observed	Chilika Lake	Pulicat Lake
Soil types / composition	Silty- clay	Sandy- silt
Density of seagrass cover (wet g/m^2)	690 ± 270 (26-870)	1144.6 ± 694 (340-2857)
Corg (%)	0.395 (0.058-0.952	0.473 (0.026 -0.929)
Dry bulk density	1.679 (1.391-2.242)	1.098 (1.042-1.131)
Blue carbon stock (MgC/ha ±SD)	2.018 ± 0.673	0.998 ± 0.418
Seagrass area (km^2)	85.47 (Geevarghese et al., 2017)	32 (Present study)

seagrass vegetation as presented in Table 1 was lower than in Pulicat Lake as well as the extensive distribution of invasive aquatic grass *Potamogeton pectinatus* during low water salinity in Chilika Lake (Shaw et al., 2000; Geevarghese et al., 2017). Sarma et al. (1981) have highlighted the very high assemblage of phytal meiofauna of *Potamogeton pectinatus* which is manifold higher than that of seagrass *Halophila* and seaweed *Gracilaria* from this area.

Although occupying only 0.1 – 0.2% of the ocean surface, seagrass meadows are known to burry 22-44 Tg C org/year on a global scale, which accounts for 10- 18% of the total carbon burial in the oceans, their carbon stocks are comparable to that of tropical forests and tidal wetlands (Duarte et al., 2005; Fourqurean et al., 2012; Kaladharan et al., 2020). Over the last decades globally seagrass meadows have experienced drastic decline and so its standing crop (Hastings et al., 1995; Arias- Ortiz et al., 2018; Kaladharan & Anasukoya, 2019). Sufficient warning has already been sounded that any slightest decrease in seagrass vegetation cover can cause increase in CO2 emissions from soil organic carbon stored in seagrass habitats (Serrano et al., 2016; Kaladharan et al., 2020)

Based on the current carbon trading price of AU$35/ tonne in 2020 (Bedulli et al., 2020), the blue carbon stock of seagrass habitats in Chilika Lake could be worth about INR. 30188218. (402510 USD) and that of Pulicat Lake could be worth about INR.5586560 (74487 USD) besides their various ecosystem services. Hence these seagrass ecosystems should be conserved and protected from any degree of anthropogenic pressures and against natural calamities and regular assessment of blue carbon stock from these ecosystems will unravel the rate of carbon storage and its significant role in mitigating climate change impacts.

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