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ORIGINAL RESEARCH ARTICLE

Chromophoric dissolved organic matter (CDOM) variability over the continental shelf of the northern Bay of Bengal

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Summary The present paper dealt with the annual dynamics of the absorption coefficient of chromophoric dissolved organic matter at 440 nm $\{a_{CDOM}(440)\}$ during February 2015 to January 2016 in the continental shelf of northern Bay of Bengal (nBoB) for the first time. Sea surface salinity (SSS), chlorophyll-*a* (Chl-*a*), total suspended matter (TSM) were also analyzed. It was hypothesized that CDOM should exhibit significant spatial and temporal variability in this region. $a_{CDOM}(440)$ and spectral slope ranged between 0.1002 m^{-1}—0.6631 m^{-1} and 0.0071 nm^{-1}—0.0229 nm^{-1} respectively during the entire study period. Higher values of $a_{CDOM}(440)$ were observed in the near shore stations and gradually decreased towards the offshore. Significant seasonal variability of $a_{CDOM}(440)$ was observed between the monsoon and non-monsoon seasons ($p < 0.05$). Thus the framed hypothesis was successfully accepted by means of the present study. The CDOM was mainly found to be of allochthonous character in this region. $a_{CDOM}(440)$ portrayed a significant negative linear relationship with SSS ($R^2 = 0.80$; $p < 0.05$) implying conservative mixing of marine and terrestrial end members. However, examining the spatial variability of the relationship, it was observed that this relationship was significant only in the nearshore stations.

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While examining the seasonal variability of this relationship, it was found to be most significant during the monsoon (R^2 = 0.81; $p < 0.05$). Thus it was inferred that whenever the SSS gradient was higher, the relationship between $a_{CDOM}(440)$ and SSS was found to be most significant.

1. Introduction

The ability of coastal water to transmit sunlight to planktonic, macrophytic and other submerged vegetation for photosynthesis is one of the prime indicators of the health of coastal ecosystems. Chromophoric dissolved organic matter (CDOM) is one of the major light-absorbing constituents of the coastal waters. CDOM is found in all types of natural waters and it is capable of changing the colour of the water (Blough and Del Vecchio, 2002). It consists of a varied mixture of aliphatic and aromatic polymers that are mostly derived from the degradation of terrestrial and aquatic plant matter (Kirk, 1994). Its absorption is strongest in the ultraviolet (UV) region (Stedmon et al., 2000). This strong absorption of UV radiation by CDOM prevents the phytoplankton and other biota from being damaged in the coastal ecosystems (Blough and Zepp, 1990; Blough and Green, 1995). In higher concentration, CDOM absorption can alter the primary productivity of a coastal ecosystem by reducing the availability of photosynthetically active radiation to the phytoplankton community (Bidigare et al., 1993). Several studies were carried out on the colour signal of CDOM from the perspective of remote sensing applications, where the effect of CDOM was considered while measuring the phytoplankton and suspended sediment by means of remotely sensed data (Karabashev, 1992; Tassan, 1988). The optical characteristics of coastal and estuarine waters have a complex nature and they exhibit significant temporal and spatial variability of CDOM concentration (Keith et al., 2002). CDOM concentrations increase in coastal waters due to the anthropogenic input of industrial or domestic effluents by river discharges (Bricaud et al., 1981) along with in situ production from phytoplankton debris (Carder et al., 1989). The optical properties of CDOM also change due to the mixing of seawater with freshwater and phenomenon like photo-degradation in the coastal regions (Bricaud et al., 1981; Carder et al., 1989; Del Castillo et al., 2000; Morel, 1988; Vodacek et al., 1997).

From the perspective of characterizing the CDOM variability, very few studies are reported from the northern Bay of Bengal (nBoB) (Das et al., 2016a, 2016b). The CDOM dynamics is expected to be highly variable due to the biogeochemical complexity of this study region (Biswas et al., 2010; Mukhopadhyay et al., 2006). However, the CDOM variability data in this study region is available only for post-monsoon season (Das et al., 2016a, 2016b). In the short term study, Das et al. (2016a) walso described that among the selected physico-chemical parameters, salinity exhibited significant correlation with the absorption coefficient of CDOM at 440 nm [$a_{CDOM}(440)$] during the post-monsoon season in this study region.

Owing to the existing scarcity of spatial and temporal (especially annual) data in the present study region, we have framed this study and hypothesized that magnitudes of CDOM vary both spatially and temporally in the near shore to the offshore transition zone of nBoB. The absorption coefficient of CDOM was measured at 440 nm [i.e., $a_{CDOM}(440)$] since it is implemented directly in various remote sensing applications. The first objective of the present study (in accordance with the proposed hypothesis) was to examine the spatial and temporal (monthly or seasonal) variability of CDOM throughout one annual cycle (February 2015—January 2016). The second objective of the study was to determine whether the CDOM in this region is autochthonous or allochthonous in nature. The third objective was to examine that whether the pre-existing relationship between CDOM and salinity observed by Das et al. (2016a) during their short term work holds true for the entire annual cycle or not in the present study region.

2. Study area

The present study was conducted in the near shore to offshore transition zone of nBoB (Fig. 1). This study region is located in the shallow continental shelf (<20 m bottom depth) off the coastline of the state of West Bengal, India. This area receives a substantial amount of freshwater discharge as well as total suspended matter (TSM) from the perennial River Hugli flowing by the megacities of Kolkata and Howrah (Das et al., 2015; Mukhopadhyay et al., 2006). Therefore, a substantial amount of terrestrial organic matter mixes in the present study region all through the year. This discharge peaks during monsoon (Unger et al., 2003; Varkey et al., 1996). The present study area receives the freshwater flow mainly from the Farakka Barrage situated 286 km upstream from the Hugli River mouth (Biswas et al., 2010). Moreover, it is also bounded by the Sundarban mangrove ecosystem in the north. There are several other tidally influenced distributaries within the Sundarban mangroves like Saptamukhi, Thakuran, Matla, Gosaba and Bidya (from west to east) which act as a source of organic matter into the study region (Das et al., 2015). This region is characterized by an intense semidiurnal tide of meso-macrotidal nature (2.5—7 m) (De et al., 2011). The study site is also affected by episodic events, such as heavy precipitation associated with land drainage, cyclones and seasonal coastal upwelling, that bring significant quantities of nutrients to the photic layer (Maneesha et al., 2011) along with detritus loads. Previous studies also revealed that the present study region experiences a significant prevalence of organic matter (Biswas et al., 2010; Mukhopadhyay et al., 2006). The climate in this part of the world is demarcated as pre-monsoon (February—May), monsoon (June—September) and post-monsoon (October—January). About 70—80% of the rainfall occurs between June and September (Mukhopadhyay et al., 2006). The south west monsoon driven rainfall enhances