Observations on phytoplankton bloom dynamics during winter monsoon in Arabian Sea: a comparative analysis using Oceansat-3 OCM and MODIS Aqua Satellite data

N. A. Anisha[1,*], Ranjit Kumar Sarangi[2] and M. P. Prabhakaran[1]

[1]Department of Aquatic Environment Management, Kerala University of Fisheries and Ocean Studies, Kochi 682 506, India
[2]Agriculture, Forestry and Ecosystem Sciences and Applications Group/Earth and Planetary Sciences and Applications Area, Space Applications Centre, Indian Space Research Organisation, Ahmedabad 380 015, India

The Arabian Sea is among the most productive basins in the global ocean, and it is important in the context of reversal of monsoon, eddies, convection processes, winter cooling and significant upwelling phenomena. These processes influence the biogeochemical properties of the region. The formation of a phytoplankton bloom in the Arabian Sea during the winter monsoon is an example of biophysical coupling. Low sea surface temperature (SST) and high nitrate concentration result in enhanced concentration of chlorophyll-a (Chl-*a*) which is considered as the signal of phytoplankton bloom. The present study is carried out using Oceansat-3 Ocean Colour Monitor (OCM) and Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua derived Chl-*a*, SST, photosynthetically active radiation (PAR), and modelled nitrate nutrient image analysis to study details of phytoplankton bloom dynamics on a weekly and monthly scale. The study has been carried out using the satellite data during the winter monsoon (November 2023 to February 2024) using 8-day composite/weekly-scale data and respective monthly data. Chl-*a* concentration ranged between 0.3 to 1.1 mg m^{-3}, SST ranged 26.98°C–29.38°C, PAR ranged 35.87–50.26 Einstein m^{-2} day^{-1}, nitrate ranged 2.3–4.1 μ mol/L during the winter monsoon. The peak bloom condition is observed in the month of February during the winter monsoon. But PAR is observed to be increased in the peak bloom stages. Nitrate is the major controlling factor for the formation of bloom as compared to other parameters. OCM-3 data is showing matching results with MODIS data with little overestimation. The present study proves the suitability of the Oceansat-3 OCM sensor data for bloom observation in the Arabian Sea during the winter monsoon from its initiation phase to its peak phase and for understanding the dynamics and correlation of Chl-*a*, SST, PAR, and modelled nitrate with phytoplankton biomass variability in bloom and non-bloom sites.

Keywords: Arabian Sea, chlorophyll, MODIS-Aqua, Oceansat-3 OCM, phytoplankton bloom.

THE Arabian Sea (AS) is one among the highly productive regions in the tropical oceans, and its boundary and open ocean processes are impacted by summer upwelling and winter cooling, which introduces large amounts of nutrients into the upper ocean, improving primary production and eventually the fisheries[1]. In recent years, the phytoplankton blooms are observed at regular intervals and are being reported in the Arabian Sea, mainly occurring during winter monsoons[2,3]. Such blooms tend to increase in species cell density over the time period. Phytoplankton consists of small, single-celled organisms, which constitute the base of the oceanic food web. The abundance of phytoplankton in the oceans is controlled by biophysical processes and anthropogenic and climate-induced variables. Hence, the phytoplankton growth, which leads to a bloom, is triggered by spatiotemporal variation in water quality parameters[4,5]. The spatio-temporal observations of phytoplankton blooms on a synoptic scale have been possible through space technology via satellites with larger area coverage[6]. The *in situ* based measurements are not cost-effective and have limitations to cover a broad area in a short time span. Remote sensing observations have been vital to estimate and monitor important ocean parameters such as chlorophyll-*a* (Chl-*a*) concentration, phytoplankton absorption, sea surface temperature (SST) and photosynthetically available radiation (PAR) over large areas. Satellites are capable of estimating various parameters in surface waters on a synoptic scale by measurement of spectral changes of the upwelling light. Satellite sensors observe and quantify the colour of the ocean surface, providing valuable information about various parameters and processes. This approach, known as ocean colour remote sensing, measured by satellites, unveils chlorophyll content, a key proxy for phytoplankton biomass. Ocean colour satellite sensors like the Sea-viewing Wide Field-of-View Sensor (SeaWiFS), Moderate Resolution Imaging Spectroradiometer (MODIS)-Aqua, Ocean Colour Monitor (OCM), Visible Infrared Imaging Radiometer Suite (VIIRS), etc. have successfully mapped and visualised the phytoplankton biomass in terms of Chl-*a* concentration on a regional and global scale[7]. Oceansat-3 satellite configured and launched into orbit to measure physical, biological and atmospheric parameters. Its sensor, OCM-3, is designed for providing quantitative information of ocean colour variables, e.g., Chl-*a* concentration, total suspended matter, etc. It is operating in two modes: (i) local area coverage at 366 m resolution and (ii)

*For correspondence.(e-mail: anishaanilsac@gmail.com)