Impact of southwest monsoon on the variability of chlorophyll-a in the coastal waters off Mangalore to Malpe, west coast of India

Vinaya Kumari P[1], K. S. Jayappa[1], Sujitha Thomas[2], Mansi Joshi[1]

[1]*Department of Marine Geology, Mangalore University (India)*

[2]*ICAR-Central Marine Fisheries Research Institute, Mangalore RC Hoige Bazar (India)*

ABSTRACT

Coastal waters are dynamic in nature and the most productive ecosystems. Proliferation in anthropogenic activities has often led to raise pressure on the coastal ecosystems. An upsurge in greenhouse gas emissions has influenced rainfall over oceans and land. Rainfall is one of the factors which affect the quality of coastal waters. Nutrients carried by the rivers have an excessive influence on the spatio-temporal fluctuation of chlorophyll in coastal waters. Rainfall increases the flow of fresh nutrient rich waters to the sea. Changes in the environmental parameters of coastal waters off Mangalore to Kodi Bengre was studied from February-September 2017 with a view of understanding the influence of southwest monsoon on distribution of chlorophyll-a (chl-a). Southwest monsoon rainfall (June-September) ranged between an average of 17.19 and 44.32 mm/day. During monsoon chl-a varied between 1.68 and 15.2 mg/m^3 and its concentration reached the peak in the month of August. Intensification in chl-a during monsoon may be attributed to the availability of nutrients. Analysis of association between rainfall and chl-a increases our understanding on the ocean productivity. Spatio-temporal variations in the rainfall combined with increased nutrient discharge due to anthropogenic activities could have triggered changes in chl-a and affects the primary productivity.

Keywords: Chlorophyll-a, Primary Productivity, Southwest monsoon

I. INTRODUCTION

The ocean covers > 70% of the earth's surface and it contributes ~ 80% of world's photosynthesis. Ocean biology is important not only for fish production, but also for impact on biogeochemical cycling, including controlling ocean surface CO_2 by the flux of carbon from the surface to the deep ocean [1]. Water quality of the coastal area has already undergone major changes due to increase in human activities [2].

Nutrient enriched waters carried by the rivers and discharge of effluents acts as the major sources of nutrients to the Arabian Sea. Increase in chlorophyll is related with upstream discharges that bring nutrient rich water to the sea [3]. Ocean productivity differs with the season and also varies in case I and case II waters. This variation can be measured by the concentration of chlorophyll present in the water. Chlorophyll is essential to the existence of phytoplankton - single-celled microorganisms - that dwells on the surface of the sea. Phytoplankton growth varies seasonally and it can be used as a bio indicator that deliver information on alterations in the environment and water quality. The human-induced changes affected the rate of precipitation, which have modified the availability of nutrients and light, thereby influencing ocean primary productivity. Therefore, to predict future changes in ocean biogeochemistry, it is critical to determine how precipitation influences phytoplankton in the modern ocean [4].

Sea Surface Temperature (SST) and nutrients are the important factors which affect the growth of phytoplankton [5]. Changes in the concentration of chlorophyll can indicate changing sea temperatures which can be attributed to climate change. Ocean biogeochemical models predict that as the sea surface temperature increases the phytoplankton productivity decreases. Naqvi et al. (2010) investigated the long-term trends in chlorophyll and SST in the Arabian Sea, to understand the factors that control primary production (PP) [6]. The surface enrichment and phytoplankton bloom could play an important role in sustaining the rich fishery resources [7].

The present study reveals that chl-a is experiencing seasonal variability and influenced by the monsoon. By using the satellite derived rainfall data and in-situ chlorophyll-a data, we were able to investigate the chl-a variability precisely. A comparative study of seasonal chl-a variation along the Mangalore to Malpe coast during pre-monsoon and monsoon seasons is revealed.

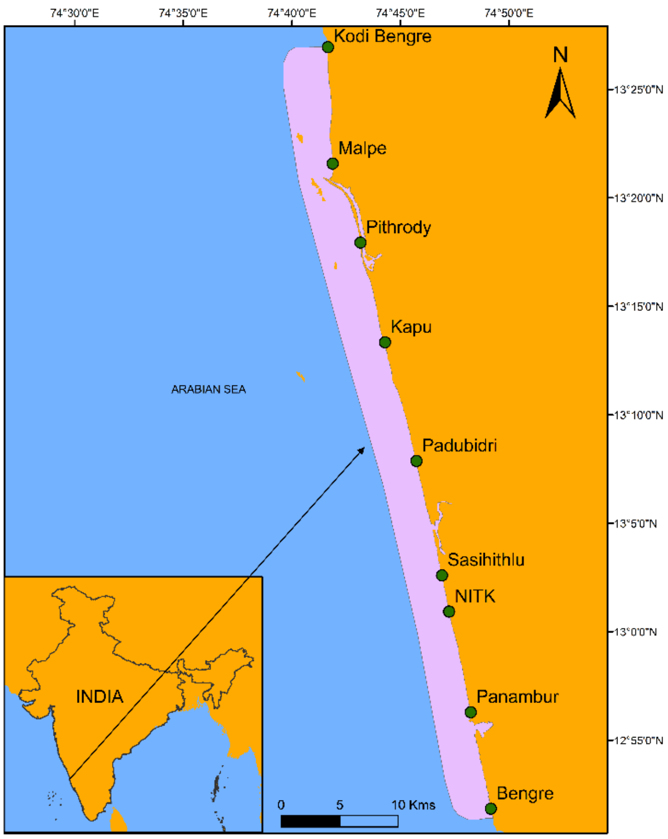

Fig 1: Study Area

1. Study area:

Coastline of Karnataka measures a length of 320 km. It's one of the most ecologically sensitive and fragile area which comprises of estuaries, wetlands, creeks, barrier and braided islands, spits, dunes, sandy beaches, mangroves, headlands and bays. Dakshina Kannada and Udupi districts in the state of Karnataka extend over 130 km of coastline. The rivers that drains in the study area are: Netravathi, Gurupura (Phalguni), Shambhavi, Nandini (Pavanje), Payaswini, Udyavara, Sita-Swarna join the Arabian Sea [8].

The study area has a tropical monsoon climate and has the influence of southwest monsoon. It receives about 95% of its total annual rainfall during southwest monsoon (June-September). The average annual rainfall received along the coastal areas of Karnataka is about 3456 mm. For the present study, Bengre, Panambur, Surathkal, Sahihitlu, Padubidri, Kaup, Pithrody, Malpe and Kodi Bengre stations were selected (Fig. 1).

2. Materials and methods

Seawater samples were collected at monthly intervals from surface from the above mentioned nine stations from February to September 2017. All these water samples were stored in polythene bottles and transported to the laboratory. They were analysed within 24 hours of collection. For chlorophyll pigment analysis, one litre of sample was filtered using Whatmann GF/F filter paper. Then the filter paper was treated with 90% acetone and kept in dark for 24 hours at low temperature. Extract was centrifuged and the clear supernatant was measured spectrophotometrically. The equation of Parsons and Strickland, (1972) was used to estimate chl-a [9].

Rainfall parameter has been derived using INSAT-3D satellite data products. The ground resolution at the sub-satellite point is nominally one km x one km for visible and SWIR bands, 4 km x 4 km for one MIR and both TIR bands and 8 km x 8 km for WV band. Level 2B HEM (Hydro-Estimator) data has been used for the present study. The rainfall parameters were then retrieved using python. The study area of interest was cropped from the satellite data and the area average for that particular region was calculated using desired algorithm in python. Raster models have been created through Inverse Distance Weighted (IDW) interpolation methods in ArcGIS platform to show the distribution of the parameters.

3. Results and discussions:

In the study area, during pre-monsoon season there was no rainfall recorded from February to April when chl-a values ranged from 0.59 to 8.21 mg/m^3. Minimum chl-a value was recorded in the month of February at Panambur station. This may be because of the depletion in nutrient levels. An average rainfall was recorded in the study area in the month of May was 15.011 mm/day when chl-a varied from 2.36 to 9.2 mg/m^3.

Southwest monsoon rainfall ranged between an average of 17.19 and 44.32 mm/day from June to September and chl-a varied between 1.68 and 15.2 mg/m^3. Maximum chl-a value of 15.2 mg/m^3 was recorded at Bengre in the month August. Krishna Kumar (2007) has recorded that surface chl-a varied from below detectable limit to 18.59 mg/m^3 [10]. The chl-a content was high in April and August. High chlorophyll conc. can be linked with high amounts of organic matter being delivered to the sea. Higher rainfall increases nutrients level to be carried into sea by rivers which stimulates increases in chlorophyll. Sulochanan et al. (2004) have observed chl-a value from 1.363 to 56.19 mg/m^3 during and after the bloom period in the coastal waters off Mangalore [11]. The result is strongly influenced by seasonal wind shifts (monsoon) that dominate the area. Rainfall varied between

2.77 and 262.98 mm/day in the month of June with average of 44.32 mm/day. Lowest chl-a value of 1.68 mg/m^3 was recorded at Pithrody during monsoon season. Rajesh et al (2002) have observed similar values of chl-a ranging between 2.83 and 9.71 mg/m^3 with higher values recorded in monsoon season [12].

The seasonal time series plots (Fig. 2a and 2b) indicate that there is peak in chl-a during April month in Bengre station. This may be induced by anthropogenic influx of nutrients from the Mangalore port area. The study by Padmakumar et al. (2012) indicated that the growth of harmful algal blooms in Indian waters may be due to rise in anthropogenic activities enrichment of the coastal waters or other eutrophication such as intensified coastal aquacultural farming, release of ballast water drawn from port area [13]. Intensification of phytoplankton occurred during the monsoon period, which may be triggered by cold and nutrient rich waters. There is less chl-a in June when compared with other monsoon months. This short delay may be because of the time taken by phytoplankton to use the available nutrients for their growth. Pre-monsoon and monsoon chl-a variations are represented by distribution maps generated by using Inverse Distance Weighted (IDW) interpolation method (Fig. 4a and 4b).

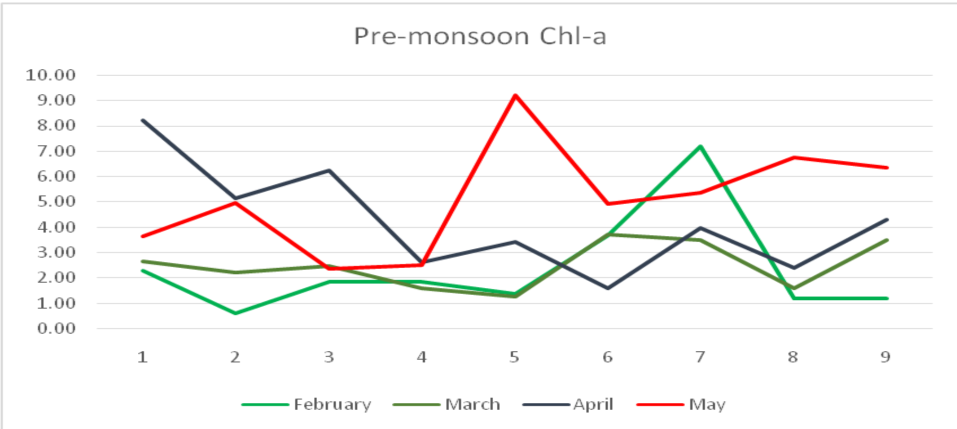

Fig. 2a: Monthly variation of chl-a during pre-monsoon

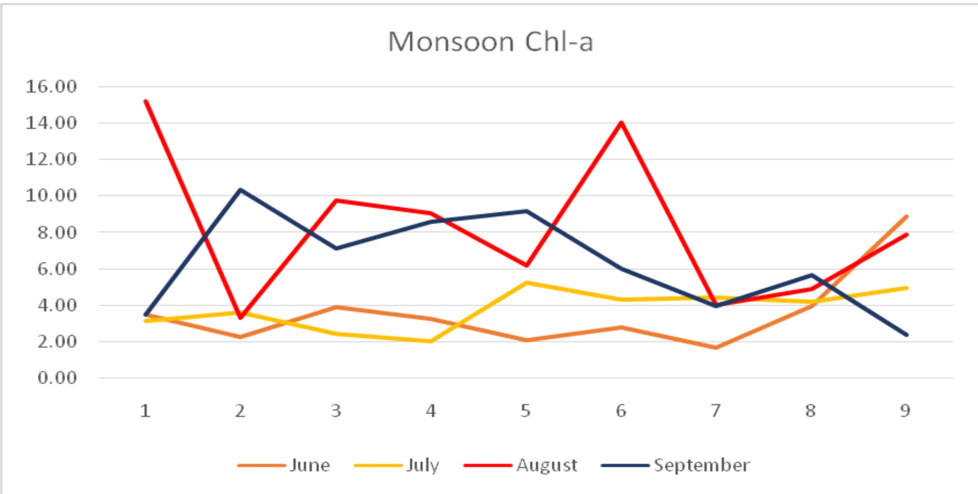

Fig. 2b: Monthly variation of chl-a during monsoon

 ISBN: 978-93-86171-72-6

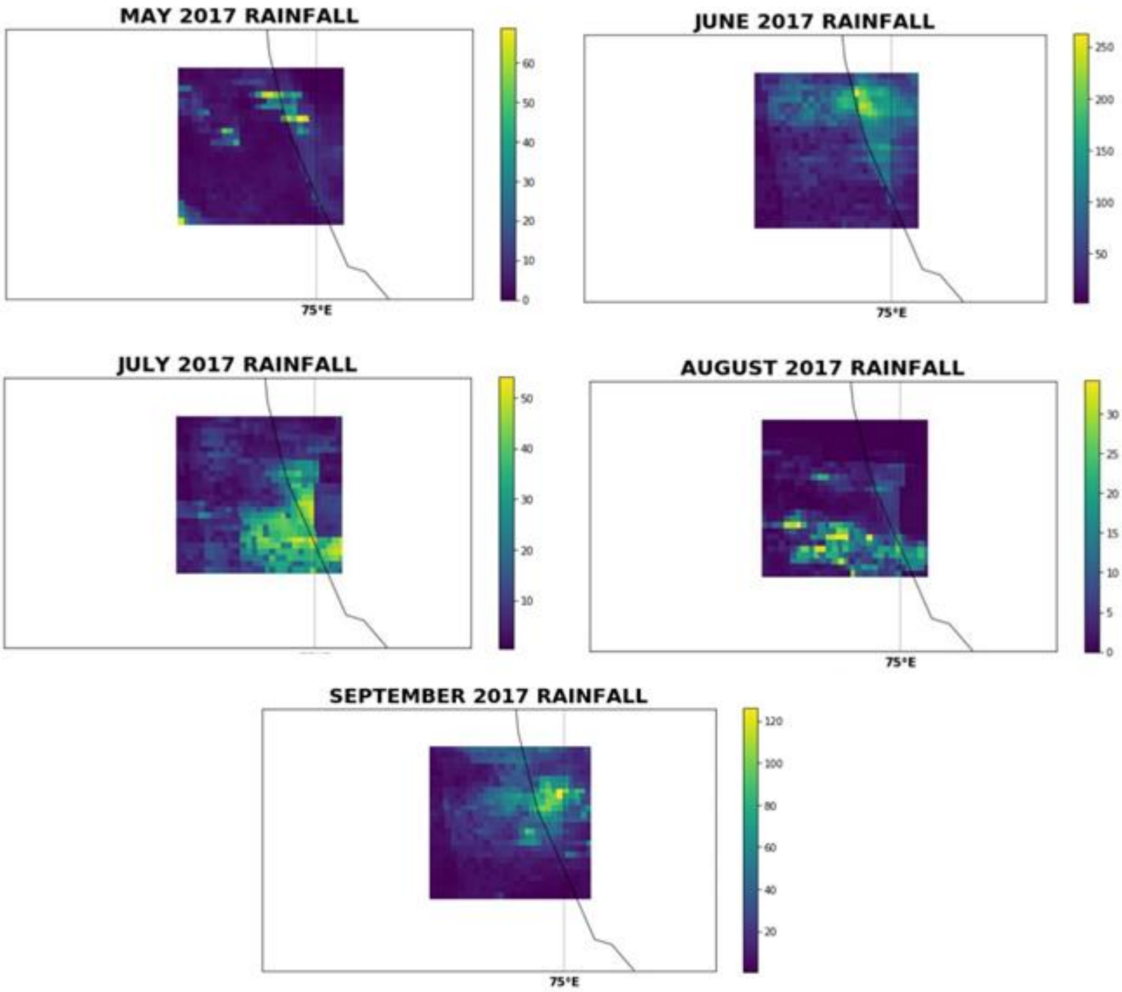

Fig. 3: Rainfall plots from May to September

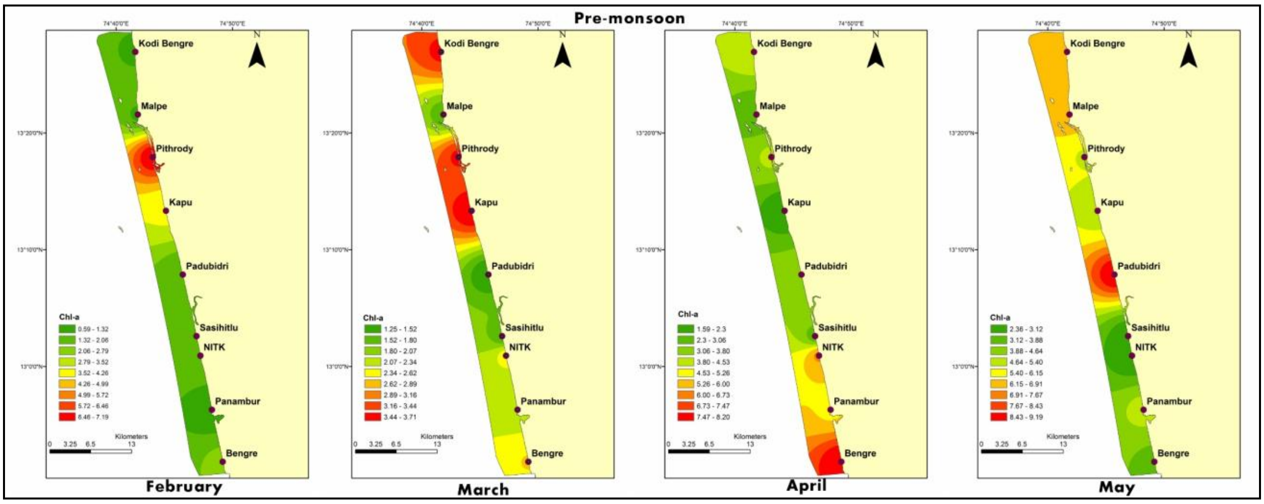

Fig. 4a: Chl-a distribution map during pre-monsoon season

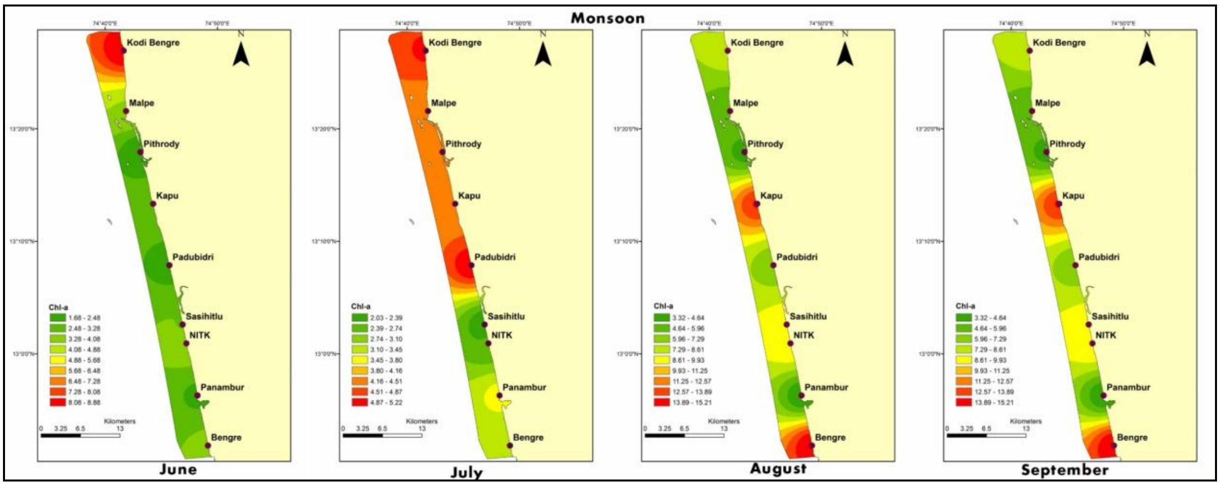

Fig. 4b: Chl-a distribution map during monsoon season

II. CONCLUSIONS

Chl-a can be taken as an indicator to study the primary production which influences coastal ecosystems. Reduction in PP may lead to the negative impact on marine life which affects the food web and economic sectors like fishing and aquaculture. Discharge of effluents from industries causes serious damage to the coastal ecosystems as it stimulates the growth of algae and causes hypoxia. The effect of hypoxia leads to mass death of several marine species. An attempt has been made in this study to find out the role of precipitation on chl-a variations and ocean productivity.

III. ACKNOWLEDGEMENTS

The authors are grateful to the University Science Instrumentation Centre (USIC), Mangalore University for providing the lab and instrument facilities.

REFERENCES

[1.] Krishna MK, Song G, Kantham NL, Bio-physical Changes in the Eastern Arabian Sea due to Ocean-Atmospheric Teleconnection, Journal of Geology & Geophysics,3:165, 2014.

[2.] Goudie, A., The Human Impact on the Natural Environment (3rd ed., Basil, Blackwell, 1990).

[3.] Tang, D. L., B. Satyanarayana, R. P. Singh and H. Zhao, Satellite Remote Sensing of chlorophyll-a distribution in the Northeast Arabian Sea, Proc. 31st International Symposium on Remote Sensing of Environment (ISRSE), St. Petersburg, Russia, 2005, CD ROM publication.

[4.] Kim, T. W., Najjar, R. G., & Lee, K., Influence of precipitation events on phytoplankton biomass in coastal waters of the eastern United States, Global Biogeochemical Cycles, 2014, 28(1), 1-13.

[5.] Tang, D.L., Kawamura, H., Lee, M.A. and Dien, T.V. 2003. Seasonal and spatial distribution of chlorophyll-a concentrations and water conditions in the Gulf of Tonkin, South China Sea, Remote Sens. Environ., 85, 2003, 475-483.

[6.] Naqvi, S. W. A, Moffett, J. W., Gauns, M. U., Narvekar, P. V., Pratihary, A. K., Naik, H., Ahmed, S. I., The Arabian Sea as a high-nutrient, low-chlorophyll region during the late Southwest Monsoon, Biogeosciences, 7(7), 2010, 2091–2100.

[7.] Tan, C. K., Ishizaka, J., Matsumura, S., Yusoff, F. M., & Mohamed, M. I. H., Seasonal variability of SeaWiFS chlorophyll a in the Malacca Straits in relation to Asian monsoon. Continental Shelf Research, 26(2), 2006, 168-178.

[8.] Report, State of the environment, Coastal zone management, 2003, 34.

[9.] Strickland, J. D. H., & Parsons, T. R., A Practical Handbook of Seawater Analysis. A Practical Handbook of Seawater Analysis, 167, 1972, 185.

[10.] Krishnakumar, P. K., & Bhat, G. S., Seasonal and interannual variations of oceanographic conditions off Mangalore coast (Karnataka, India) in the Malabar upwelling system during 1995–2004 and their influences on the pelagic fishery. Fisheries Oceanography, 17(1), 2008, 45-60.

[11.] Sulochanan, B., Dineshbabu, A. P., Saravanan, R., Bhat, G. S., & Lavanya, S., Occurrence of Noctiluca scintillans bloom off Mangalore in the Arabian Sea, Indian Journal of Fisheries, 61(1), 2014, 42-48.

[12.] Rajesh K M., G. Gowda., Mridula, R., Primary Productivity of the Brackishwater Impoundments along Nethravathi estuary, Mangalore in Relation to Some Physico-chemical Parameters. Society of Fisheries Technologists, 39(2), 2012, 85-87

[13.] K. B. Padmakumar, N. R. Menon, and V. N. Sanjeevan, “Is Occurrence of Harmful Algal Blooms in the Exclusive Economic Zone of India on the Rise?”, International Journal of Oceanography, 2012.