Proc. Symp. Mar. Chem. in the Arab Region, Suez, April, 1991 : 113 - 120

Distribution of Chlorophyll "a" and Phosphate in The Waters of Gulf of Aden

By

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Abstract

During the cruise of R.V. Skif in the months of August and October 1986, water samples were collected from a total of 52 stations covering major areas of the northern and northeastern parts of the Gulf of Aden. Analysis of the data showed a very close relationship existing between phosphate and chlorophyll 'a' values. The highest value of 1.65 ug at/1 and 2.41 mg/m³ for phosphate and chlorophyll 'a' respectively were recorded during August (southwest monsoon) from the northeastern part. During October (northeast monsoon) the corresponding values exhibited a shift in the concentration from east to west due to the changes in circulation and the cessation of upwelling.

Introduction

The oceanographic information available for the Gulf of Aden region is mainly from the IIOE (International Indian Ocean Expedition) results and other publications based on different investigations carried out by the Norwegian and Russian vessels in the northern Indian Ocean. Koblentz Mishke et al. (1970) estimated the primary production of the Indian Ocean to be 75% greater than Pacific and 17% than the Atlantic Oceans. A comprehensive study of the primary production of the Indian Ocean region was made by Ryther et al. (1966), Kabanova (1961, 1968), Krey and Babenerd (1976) and Qasim (1977). Jacob et al. (1979) studied the oceanography, primary and secondary production in the coastal waters of Kuwait. Dorgham and Moftah (1989) reported the environmental conditions and phytoplankton distribution in the Arabian Gulf and Gulf of Oman. The report on the scientific investigations (Stirn et al. 1985) provides some preliminary information on the nutrients (Ghaddaf and Al-Sayed, 1986) and phytoplankton (Mutlag and Hayadarah, 1986) in the northern and northeastern waters of Gulf of Aden. Phosphate and chlorophyll play a very important role in determining the primary productivity of the sea. In the present paper an attempt has been made to find out the nature of relationship existing between the phosphate content and chlorophyll "a" in the surface waters of Gulf of Aden during two seasons.

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Material and Methods

The data collected during the two seasonal cruises of **R.V. Skif** covering the waters of Gulf of Aden from August 6 to 22nd and October 10 to 28th 1986 were made use of for this study. A total of 52 surface water samples were collected from 8 transects (Fig. 1) using Van Dorn water sampler. Phosphate was estimated on board using spectrophotometer by the standard methods of Murphy and Riley (Koroleff, 1976). Phytoplankton samples were preserved in 2% formalin buffered with borax. Chlorophyll sample of about 1 to 2 litres was immediately filtered through millipore filter (0.47 microns) and the residue preserved in deep freeze. Estimation of chlorophyll "a" was made spectrophotometrically by the acetone extract method and applying the trichromatic formula. The map showing the distribution of phosphate was prepared by contouring the actual values plotted against the corresponding station numbers (Fig. 1) Histograms showing the phosphate-chlorophyll "a" relationship have been made based on their average values for each section (Fig. 2). This relationship has also been presented in figure 3.

Results

During August (southwest monsoon) the values of phosphate and chlorophyll "a" were found to be in very close proportion at all the eight sections. Along the Imran transect the average values of phosphate and chlorophyll "a" were 0.676 ug at/1 and 0.477 mg/m^3 respectively. These values were found to be reduced gradually in the Aden and Shuqra transects reaching the minimum value of 0.348 ug at/1 and 0.291 mg/m^3 in Irka transect. The higher values of 1.555 ug at/1 and 1.645 mg/m^3 for phosphate and chlorophyll "a" respectively were recorded in the Ras Faroak transect. All the transects from Ras Alkalb to east showed a steady increase in values for both, the highest being off Ras Fartak. The nature of the relationship of phosphate and chlorophyll "a" along transects from Ras Fartak to Socotra and Socotra to Ras Asir were of a different nature unlike in the other transects, having higher values of chlorophyll "a" than phosophate.

During October unlike the southwest monsoon period the values of chlorophyll "a" were always higher than phosphate in all the transects particularly off Aden, Shuqra and Qusyr, where they were more than double that of phosphate values. The lowest values were observed from Ras Alkalb transect. At Ras Fartak and Socotra the difference was negligible. Chlorophyll had the highest value (0.86 mg/m^3) along the Shuqra transect and lowest (0.37 mg/m^3) along Ras Alkalb transect, whereas for phosphate they were off Ras Fartak (0.55 ug at/1) and Shuqra (0.2 ug at/1) respectively.

Discussion

The value of phosphate in the month of August at one station along Ras Fartak section rose up to 1.655 ug at/1, but found fluctuating considerably and decreasing

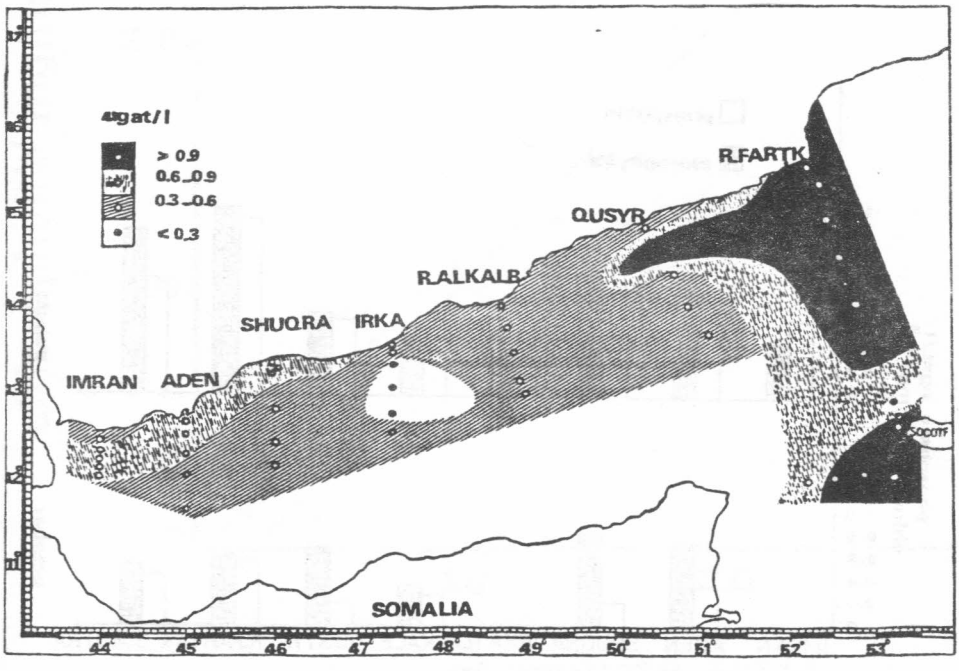
µgat/l
> 0.9
0.6_0.9
0.3_0.6
< 0.3
R.FARTK
QUSYR
R.ALKALB
SHUQRA
IRKA
IMRAN
ADEN
SOCOTF
SOMALIA
44°
45°
46°
47°
48°
49°
50°
51°
52°
53°

Fig. (1)

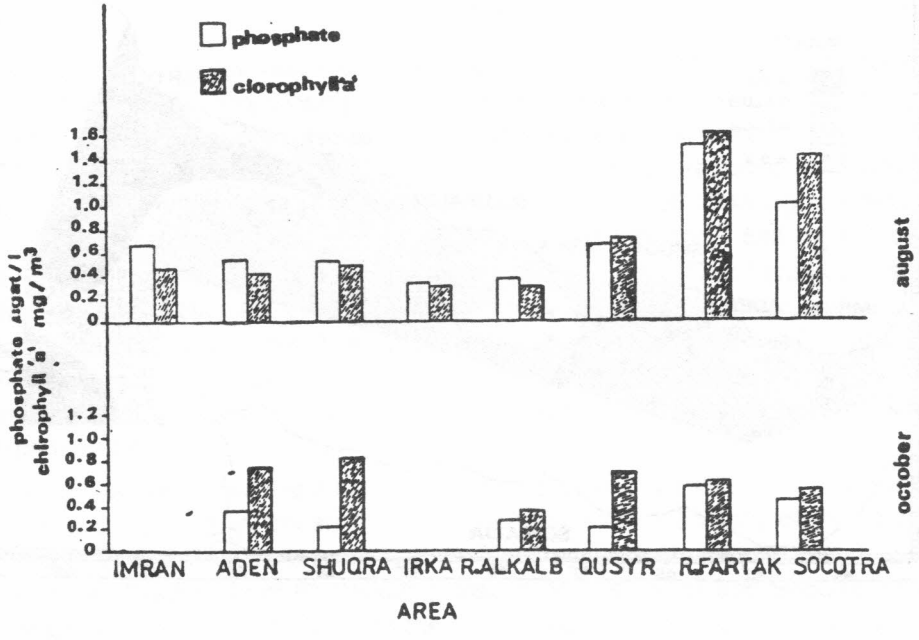
phosphate
clorophyll'a'
phosphate µgat/l
chlorophyll 'a' mg/m³
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
august
october
IMRAN
ADEN
SHUQRA
IRKA
R.ALKALB
QUSYR
R.FARTAK
SOCOTRA
AREA

Fig. (2)

AREA

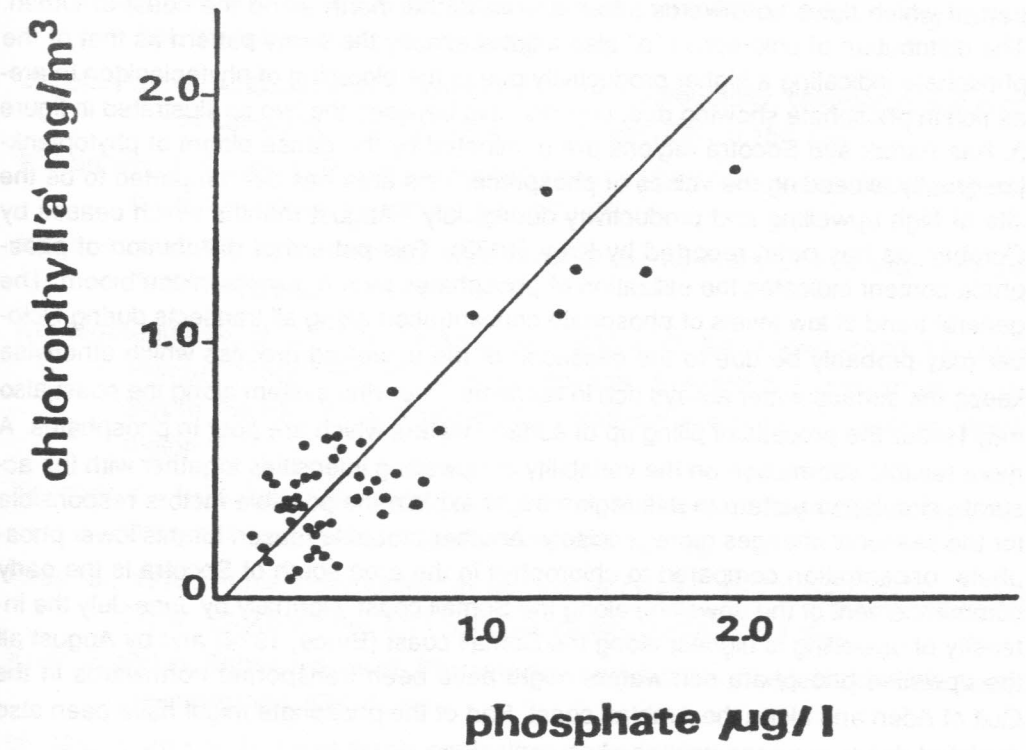

Fig. (3)

phospate ug at/l

from northeast to southwest with the minimum value (0.3 ug at/1) at Irka transect. The high phosphate concentrations in the coastal regions of Ras Fartak and southern part of Socotra Island coincided with the regions of intense upwelling. The coastal areas of Imran, Aden and Shugra also exhibit comparatively high values of phosphate during this period, indicating the probable effects of upwelling. The low values noticed at Irka and Ras Alkalb sections could be the lesser effect of upwelling at these regions. Upwelling of variable intensity is reported to occur along the coasts (Boze and Tomczak, 1975) depending mainly upon the influencing factors like wind stress and acceleration of the vertical movements due to the changing current regime. Even along the southwest coast of India such patchiness in the intensity of upwelling is noticed in the shelf waters (Anonymous, 1980). The reason why higher concentrations are noticed of Ras Fartak may be due to the intense upwelling and the advection of the upwelled water off Somali region brought into this area due to the intensification of Somali current, a part of which flows northwards into the area further north along the coast of Oman. The distribution of chlorophyll "a" also follows exactly the same pattern as that of the phosphate indicating a higher productivity due to the blooming of phytoplankton in areas rich in phosphate showing direct relationship between the two as illustrated in figure 3. Ras Fartak and Socotra regions are dominated by the dense bloom of phytoplankton greatly exceeding the values of phosphate. This area has been reported to be the site of high upwelling and productivity during July - August months which ceases by October, as has been reported by Krey (1973). This pattern of distribution of phosphate content indicates the utilization of phosphates by the phytoplankton bloom. The general trend of low levels of phosphate concentration along all transects during October may probably be due to the cessation of the upwelling process which otherwise keeps the surface water always rich in nutrients. The wind system along the coast also may favour the process of piling up of surface waters which are poor in phosphates. A more reliable information on the variability of upwelling intensities together with the accurate circulation pattern in this region might explain the possible factors responsible for the seasonal changes more precisely. Another probable reason for this lower phosphate oncentration compared to chlorophyll in the area south of Socotra is the early commencement of the upwelling along the Somali coast. Normally by June-July the intensity of upwelling is highest along the Somali coast (Bruce, 1974) and by August all the upwelled phosphate rich waters might have been transported northwards in the Gulf of Aden and along the Arabian coast. Part of the phosphate might have been also depleted due to the consumption of phytoplankton.

Acknowledgement

The authors are thankful to the Director, Marine Science and Resources Research Centre, Aden, for the facilities given and to M/S E. Al-Jumb and A. Al-Fure for the assistance rendered in the laboratory as well as in field. Thanks are also due to Mr. F. Mutlag and Mr. S.H. Hayadarah for providing the chlorophyll data.

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