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# Physicochemical Characteristics of Coastal Waters of Mangalore – Premonsoon Scenario

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**Abstract**

The premonsoon levels of temperature, salinity and nutrients (nitrite, nitrate, phosphate and silicate) were investigated in twenty-one coastal surface water samples of Mangalore to know their recent nutrient status. Analytical ranges of temperature (29-32°C) and salinity (35.34-38.00) were within the range of previous investigations and correlated well with high solar insolation and associated evaporation during summer period. Lower concentrations of nitrite (0.375-0.907 µg-at/l) and silicate (3.734-12.941 µg-at/l) were attributed to reduced river (Netravati-Gurpur) discharge as well as biological activities. When compared to previous decade, slightly higher levels of nitrate (1.623-4.178 µg-at/l) and phosphate (0.538-7.971 µg-at/l) obtained here suggest additional anthropogenic (industrial and urban effluents) input into the coastal waters of Mangalore.

**Key words**: Nutrients, River input, Anthropogenic sources, Coastal waters, West Coast of India

## Introduction

It is well known that coastal waters of the West Coast of India are one of the most productive areas of the world ocean attributed to summer monsoon induced upwelling, mud banks and nutrient enrichment (Miridula *et al.*,2002). Equally known is that the coastal regions in the vicinity of urban areas receive large quantities of domestic wastes and industrial effluents, and indiscriminate discharge of wastes and effluents may cause irreparable damage to the productivity, in turn, the entire marine ecosystem (Devassy *et al*., 1987). Studies related to nutrient availability in estuaries and coastal waters, therefore, have been increased as threat of pollution in these water bodies had multiplied few times when compared to their nutrients level in pre-industrial era. Though several authors have attempted to understand the dynamics of nutrients and their role in the productivity of waters along both coasts of our Indian subcontinent (Naqvi and Qasim, 1983; Sengupta *et al.*,1980; Hares Kumar and Matthew,1997), we are not having firm consensus about nutrient fluctuations because of the lack of season-wise information. Further, every year's seasonal information about nutrients is very important to predict climate change and anthropogenic influence on the fragile coastal ecosystem as dramatic fluctuations in nutrient availability have been more pictorial in many coastal and estuarine waters. Hence, the present study was carried out to know the nutrient status of the coastal waters, off Mangalore, especially during premonsoon season of 2003 with an aim to avoid dilution effect by copious SW monsoonal rainfall.

## Materials and Methods

### Study area

The study area (Lat.: 12˚ 47' 76"-12˚ 55' 96" N; Long.: 74˚48' 12"-74˚ 50' 66"E; Fig.1), Netravati-Gurpur estuary and adjoining coastal waters of Mangalore, forms an important nursery ground for a variety of fishes and the coastal waters, off Mangalore, are known to support rich fisheries. However, it receives treated industrial effluents from BASF (Chemical Industry), Mangalore refineries and petrochemical industry as well as domestic sewage from Mangalore city. Although several authors have studied the nutrient availability in the coastal waters of Mangalore and Netravati-Gurpur estuary (Rivonker and Verlencar, 1990; Reddy *et al.*,1990; Segar and Hariharan,1989; Manjappa and Chandrashekhara Gupta, 1988) studies related to nutrients have not been conducted recently or more than a decade. Therefore, with an aim to get the recent nutrient status, twenty-one surface seawater samples were collected using clean plastic bucket at 5, 10 and 15 m water depths along three transects parallel to coastline (Fig.1). Temperature was measured onboard by high-resolution (0.1°C) thermometer and 500 ml of each water sample was collected separately in acid-cleaned plastic bottle for the determination of nutrients (nitrite, nitrate, phosphate and silicate) and salinity. Salinity was calculated based on the chlorinity which was determined by standard titration method (Knudsen,1901). Nutrients were estimated spectrophotometrically by adopting the procedures collectively described in Parsons *et al.*, (1984).

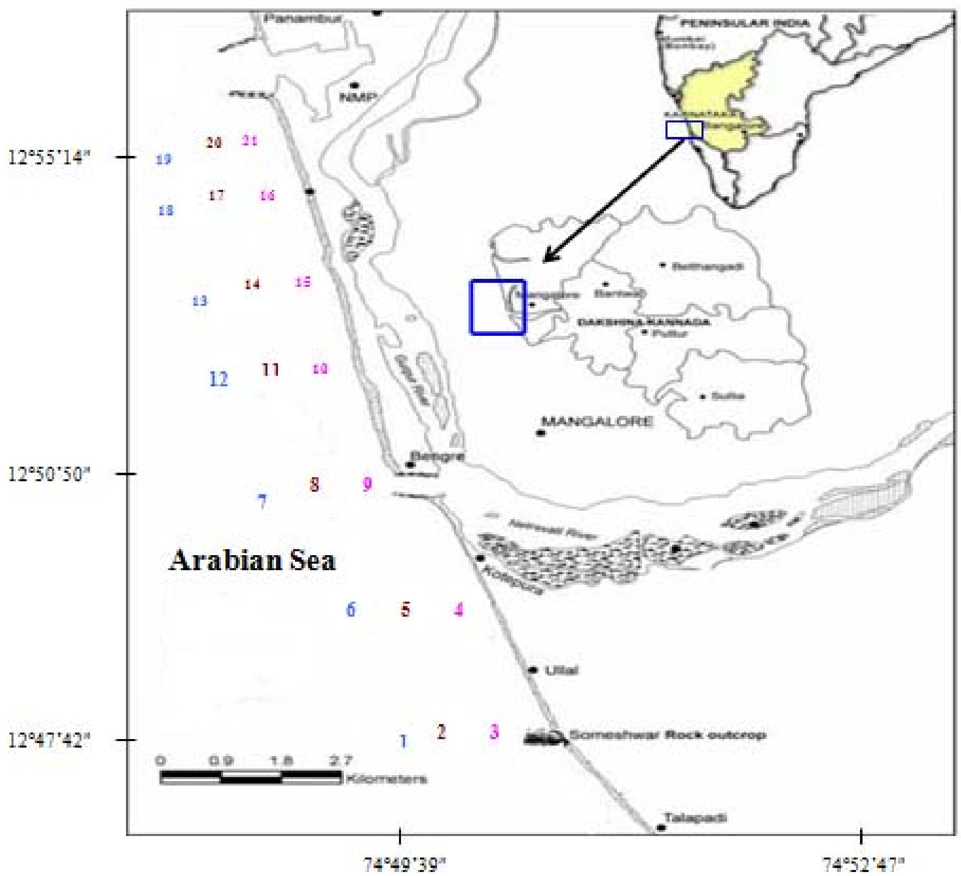


Fig.1: Map showing the location of the study area

## Result and discussion

### Temperature and Salinity

Analytical data of present study are shown in Table-1. The surface water temperature recorded minimum of 29°C and maximum of 32°C. This range is considered slightly high when compared to other seasons from earlier studies. It has been evident from the previous works that the surface water temperature usually increased from October to November in each year along this coast then the water temperature gradually reduced to minimum during the month of January. Subsequently, temperature used to increase and reached its maximum in the month of May. Higher water temperature observed here is consistent with higher sea surface temperature observed in May by Mirdula *et al*., (2002). Along the West Coast, the period of highest water temperature coincided with the period of greater insolation. (Miridula *et al.*, 2002; Rivonker and Verlencar, 1990; Ramesha *et al.*, 1992; *Suresh et al*., 1978).

Table- 1: Concentration of Nutrients and Redfield Ratios in Coastal Waters of Mangalore, West Coast of India

| S. No. | Temp. °C | Salinity ‰ | Nitrite | Nitrate | Phosphate | Silicate | N/P | Si/P |
|---|---|---|---|---|---|---|---|---|
| 1 | 29.0 | 36.76 | 0.906 | 2.214 | 4.418 | 8.951 | 0.71 | 2.03 |
| 2 | 32.0 | 36.16 | 0.688 | 2.083 | 0.538 | 3.734 | 5.15 | 6.95 |
| 3 | 31.0 | 36.96 | 0.456 | 2.211 | 1.688 | 6.845 | 1.58 | 4.06 |
| 4 | 31.0 | 36.76 | 0.590 | 2.131 | 2.896 | 6.256 | 0.94 | 2.16 |
| 5 | 31.0 | 36.56 | 0.594 | 1.623 | 3.039 | 7.110 | 0.73 | 2.34 |
| 6 | 31.5 | 36.66 | 0.897 | 2.478 | 1.790 | 8.357 | 1.89 | 4.67 |
| 7 | 31.0 | 35.76 | 0.907 | 2.065 | 0.584 | 10.485 | 5.08 | 17.94 |
| 8 | 31.5 | 35.16 | 0.825 | 2.198 | 2.988 | 6.872 | 1.01 | 2.30 |
| 9 | 31.5 | 35.16 | 0.750 | 3.079 | 0.584 | 6.496 | 6.55 | 11.12 |
| 10 | 31.5 | 35.76 | 0.500 | 2.170 | 7.317 | 8.440 | 0.36 | 1.15 |
| 11 | 31.0 | 36.16 | 0.524 | 2.499 | 1.379 | 9.786 | 2.19 | 7.10 |
| 12 | 31.5 | 38.00 | 0.406 | 2.667 | 1.753 | 10.384 | 1.75 | 5.92 |
| 13 | 31.0 | 35.96 | 0.781 | 3.350 | 1.379 | 12.941 | 3.00 | 9.38 |
| 14 | 31.5 | 36.01 | 0.672 | 3.610 | 0.876 | 9.567 | 4.89 | 10.92 |
| 15 | 31.0 | 36.36 | 0.657 | 4.179 | 0.678 | 11.611 | 7.13 | 17.13 |
| 16 | 30.5 | 35.34 | 0.500 | 2.875 | 7.971 | 4.246 | 0.42 | 0.53 |
| 17 | 30.5 | 35.56 | 0.637 | 2.436 | 4.967 | 8.590 | 0.62 | 1.73 |
| 18 | 31.5 | 35.76 | 0.563 | 2.409 | 5.119 | 9.361 | 0.58 | 1.83 |
| 19 | 32.0 | 36.16 | 0.375 | 2.698 | 1.660 | 9.258 | 1.85 | 5.58 |
| 20 | 31.0 | 35.96 | 0.375 | 3.302 | 1.800 | 6.189 | 2.04 | 3.44 |
| 21 | 30.5 | 35.66 | 0.400 | 3.177 | 1.983 | 4.179 | 1.80 | 2.11 |

All nutrients are expressed in µg-at/l.

The salinity ranges from 35 to 38‰ and the minimum value was observed near the Netravati-Gurpur river mouth (station no. 9; Fig. 1) due to fresh water input and all other stations are showing higher values. The high saline waters during the month of May were perhaps due to greatest evaporation during the peak summer. Seasonal variation of surface water salinity exhibited a tri-model oscillation with maximum value during November followed by February and May (Miridula *et al.*, 2002; Rivonker and Verlencar, 1990; Ramesha *et al.*, 1992; Suresh et al., 1978) further correlates well with our values.

**Nutrients**

The concentrations of $NO_2$-N varied from 0.375 to 0.907 µg-at/l and this range was more or less equal to previously recorded nitrite range for Mangalore nearshore waters in the month of April during 1988 (0.28 and 0.51 µg-at/l) and 1989 (0.26-0.71 µg-at/l) by Reddy *et al.*, (1990) (Table 2). When compared to few studies along this coast (Reddy and Sankaranarayanan, 1968; Eknath, 1978), our lower values of nitrite were probably attributed to reduced river input during premonsoon and euhaline condition associated with high temperature. Nitrite can enter into the coastal waters from outside sources mainly by land drainage. Previous works in this coast have observed low nitrite values, in general, other than SW monsoon period.(Reddy *et al.*,1990; Segar and Hariharan,1989) Moreover, during premonsoon season, upwelling starts at 30m water depth along this coast and the upwelled water usually reaches the sea surface in late May is also an additional cause for low nitrite values. (Devassy *et al.*, 1987).

Table -2: Range and mean concentrations of nutrients in the present study compared with previous studies in West Coast of India

| Surface/Bottom | N | Year of Study | Nitrite | Nitrate | Phosphate | Silicate | References |
|---|---|---|---|---|---|---|---|
| SW (Range) | 21 | 2003 | 0.38-0.91 | 1.62-4.18 | 0.57-0.97 | 3.73-12.94 | Present study |
| SW (Mean) | 21 | 2003 | 0.619 | 3.052 | 2.638 | 8.079 | Present study |
| SW | 4 | 1988 | 0.28-0.48 | 0.65-1.64 | 0.32-0.91 | 3.21-5.43 | Reddy *et al*., (1991) |
| | 4 | 1989 | 0.27-0.68 | 0.51-1.51 | 0.33-0.84 | 3.23-5.63 | |
| BW | 4 | 1988 | 0.33-0.51 | 0.69-1.75 | 0.16-0.88 | 1.82-3.85 | |
| | 4 | 1989 | 0.26-0.71 | 0.60-1.66 | 0.27-1.19 | 1.59-3.60 | |
| SW | 6 | 1985&1986 | - | - | 0.39 | 14.51 | Manjappa & Gupta, (1988) |
| SSW | 6 | 1985&1986 | - | - | 0.26 | 13.41 | |
| SW | - | 1985 | 0.10-3.04 | 0.12-3.04 | 0.08-1.32 | 0.80-27.00 | Rivonkar & Verlencar, (1990) |
| SW | 9 | 1981&1982 | Trace-1.56 | 0.45-15.25 | - | - | Segar & Hariharan, (1989) |
| SSW | - | - | - | 0.32-13.25 | - | - | |
| SW | 9 | 1979 | 1.48 | 1.79 | 0.30 | - | Pai & Reddy, (1981) |
| SSW | - | - | 1.78 | 2.75 | 0.29 | - | |
| SW | - | - | Trace-3.8 | Trace-28.30 | - | - | Reddy, (1977) |
| SSW | - | - | - | Trace-23.70 | - | - | |
| SW | - | - | 0.10-5.90 | Trace-16.63 | - | - | Eknath, (1978) |
| SSW | - | - | - | 0.78-11.31 | - | - | |
| SW | - | - | - | - | Trace-7.98 | - | Mridula *et al*., (2002) |

SW – Surface water; SSW – Subsurface water; All nutrients are expressed in µg-at/l.

During premonsoon period, the prevailing euhaline conditions along this coast are favorable for diatoms such as *Coscinodiscus sp*., *Chaetoceros sp*. along with *Ceratium sp*. and *Tricodesmium erythraeum* which are the main constituent of blue green algae and instant occurrence of blooms of *T. erythraeum* along Dakshina Kannada coast was also recorded (Shety *et al.*,1988; Prabhu *et al.*,1965). These blooms, however, now occur along this coast on an annual cycle. The nitrogen fixing blue-green algae is able to thrive at low nutrient concentrations (Devassy *et al.*,1987) which is also removing nutrient from the water, all together making ‘low-nutrient’ water body during premonsoon season.

The concentration of nitrate-nitrogen ranges from 1.623 to 4.178 µg-at/l and this range was high when compared to lower ranges of nitrate, 0.65-1.75 µg-at/l and 0.51-1.66 µg-at/l recorded during 1988 and 1989, respectively (Reddy *et al.*, 1990). The lower values of this stable form of nitrogen observed, in general, during January-April and October around Malpe and higher values were more prominent in sub-surface rather than surface waters. Moreover, our nitrate values were very low when compared with few earlier studies along this coast (Rivonker and Verlencar, 1990; Segar and Hariharan, 1989; Prabhu *et al.*, 1965), and the lower values were most probably attributed by poor riverine input of Netravati-Gurpur during premonsoon.

Phosphate concentrations (0.538-7.971 µg-at/l) in the analysed samples were considered as high when compared to available data along this coast (Table 2). For example, Rivonkar and Verlencar, 1990 recorded only 0.08-1.32 µg-at/l of phosphate from surface waters, off Mangalore, during 1990. Likewise, two-year study of Reddy *et al.*,(1990) also shows lower phosphate values from 0.16 to 1.19 µg-at/l. Our range, however, correlates well with reported values (Trace-7.98 µg-at/l) of Mridula *et al.*,(2002). They investigated the nearshore waters collected from the site influenced by treated industrial effluents, off Mangalore, and matching between our phosphate values and their concentration range suggesting that the phosphate in our samples are likely enhanced by industrial effluents discharged from nearby petrochemical firm; the well known major sources of phosphorus input to the estuaries and coastal waters are domestic sewage and effluents from fertilizer units.

**Silicate**

Silicon is a biologically essential nutrient to marine organisms such as diatoms, radiolarians and sponges for their growth and the formation of their skeletal materials. As a result of its biological significance, silicon exhibits strong seasonal dependence reflecting the waxing and waning of the life processes. Silicates in river waters are the chief source of silicate to estuarine and coastal waters.

Present study shows minimum of 3.734 and maximum of 12.941 µg Si-at/l. These values are lower than the annual range (0.80 to 27 µg-at/l; Table 2) recorded by Rivonker *et al.*,(1990) and Sahu (1981) also observed higher silicate values (1.02 to 31.88 µg-at/l). Reddy *et al.*,(1990), however, found lower values (1.82-5.43 µg-at/l) in nearshore waters during 1988 and 1989 (1.59-5.63 µg-at/l) which were lower than our range. The reason for the lower values obtained in our study is mainly attributable to reduced fresh water input. The occurrence of lower values might also be due to the biological activity. Ganapathi and Sarma, (1958) have observed gradual fall in silicate from November to January along the Waltair Coast as a consequence of secondary peak in phytoplankton production. They further observed minimal values during March and early April due to the outburst of diatoms.

**Redfield ratios**

Along the coastal zone, river inputs, land runoff, and industrial and urban wastewater discharges can enhance the concentration of nutrients which finally drive the system to changing limiting nutrient status. Redfield ratio does not hold well in coastal regions, where proximity of land, influence of local flora and fauna, and vigorous wave breaking lead to saturation with atmospheric $O_2$ and $CO_2$ (Sen Gupta *et al*., 1976; Kesava Rao and Indussekhar, 1987). The low average ratio of N:P (2.39) as well as its lower range (0.36-7.13; Table 1) obtained in the present study remains less than 16:1 confirming that the bioavailability of nitrate for phytoplankton growth is less than phosphate. Similarly, Rivonker and Verlencar,(1990) observed lower N:P ratios in coastal waters, off Mangalore, which fluctuated between 0.5 and 4.5 throughout their period of observation.

The average ratio of Si:P is 5.73 (range: 0.53-17.94; Table 1) and it shows the higher biological utilization of dissolved silicate. Some reports in the coastal waters show that the eutrophication by domestic wastes containing low silicates could result in the elimination of diatoms from phytoplankton communities due to silicate depletion (Telman, 1977; Ryther *et al*.,1979). During the pre monsoon, the blue green algal bloom is very common in this area because of lower input of silica and higher influence of phosphate due to domestic wastewater. Our results show the same trend because the study area is receiving considerable discharge of domestic wastewater from Mangalore city. When compared to published reports of last decade, relatively high values of nitrate and phosphate observed in the current study suggest the increased input of nutrients in the coastal waters off Mangalore which was likely attributed to land use pattern in the up-stream regions of Netravati-Gurpur and industrial discharges, respectively.

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