J. mar. biol. Ass. India, 22 (1 & 2) : 77 - 84

FURTHER STUDIES ON THE HYDROGRAPHY OF THE INSHORE WATERS OFF KARWAR

G. G. ANNIGERI*

Central Marine Fisheries Research Institute, Cochin-682 018

ABSTRACT

Study on the distribution and correlation of inorganic phosphorus and dissolved oxygen and nitrites and inorganic phosphorus at Karwar during 1965-1972 is made. The oxygen and phosphorus are inversely related at depths. The Bay waters showed high oxygen content at surfee and low content at depths and sea beds. But the waters outside the bay showed high dissolved oxygen content in the depths than at the surface. Here the subsurface waters showed supersaturations as against practically none in the bay waters. The correlation coefficient (r) obtained for dissolved oxygen and inorganic phosphorus during this investigation was 0.53 and found to be significant at 5 and 1 per cent level.

As regards the distribution of nitrites and inorganic phosphorus, there is a close parallelism between nitrites and inorganic phosphorus and which is characterised by the presence of low concentration at surface and the increasing concentration at depths. The correlation coefficient (r) was found to be not significant at 5 and 1 per cent levels, the (r) value being 0.09. Similarly, the relationship between dissolved oxygen and nitrite when studied, the correlation coefficient of 0.26 proved to be significant at 5 and 1 per cent levels.

These nutrients bear a definite linearity at all levels. As the inorganic phosphorus and dissolved oxygen show inverse relation, and as the inorganic phosphorus and nitrite bear linearity, it is obvious that the relation between dissolved oxygen must also be inverse at depths. As the plant life much depends on the concentrations of these nutrients, it is of much value to study the distribution, interrelations and fluctuations of nutrients in the sea.

INTRODUCTION

THE NUTRIENTS are essential for the growth of phytoplankton and lack of these would act as a limiting factor. Brandt (1899) opines that both light and nutrient supply control metabolic activities of phytoplankton. Several other workers (Braarud, 1935 ; Kreps and Verjbinskaya, 1930) also showed that when nutrients are exhausted phytoplankton growth becomes inhibited. Riley (1946) has indicated a close correlation between the amount of phytoplankton and nutrients.

The nitrogen cycle in the sea exhibits a course closer to that of phosphorus. The annual addition to the sea from land drainage is considerable, but compared with the store of combined nitrogen in sea water, this addition must be very small indeed (Harvey, 1955). Sverdrup *et al.* (1942) have given the ranges in the various forms of inorganic nitrogen as NO_3-N = 0.1-4.3 μg at/L ; that NO_2-N = 0.01-3.5 μg at/L and NH_3-N = 0.35—3.5 μg at/L. They state that the distribution of nutrient in the sea is the final condition brought about the by lateral currents, vertical eddy diffusion and the downward movement due to cycle of biological events.

The present account is the continuation of studies undertaken by Ramamurthy (1963) and Noble (1970) during 1954-58 and 1960-64 respectively. The data presented here from

* *Present address:* Karwar Research Centre of C.M.F.R.I., Karwar.

January 1965 to May '72 covering 117 monthly averages at each level from Karwar Bay (opposite the Karwar head), Devgad Island and the area in the neighbourhood or slightly away from Devgad Island constitutes this report. As the observations are limited to Karwar Bay and immediate vicinity, the surface values of all the localities are combined and the correlation coefficient is expressed. The same holds for middle and bottom values as well. The sea water samples at middle (5 and 10 metres) and bottom (6.5 to 31 metres) from inside and outside Karwar Bay were collected by the aid of Cassella bottle.

The author is grateful to Dr. E. G. Silas, Director, CMFRI and Dr. A. V. S. Murty for going through the paper critically and making corrections and useful suggestions in the course of this investigations.

Material and Methods

At regular intervals seawater samples were collected from Karwar and were analysed in the laboratory. Inorganic phosphate was determined by the molybdenum blue technique, using acid ammonium molybdate and dissolved oxygen by the Winkler's method. The nitrites were estimated by the Robinson and Thompson method (1948 b). For establishing the correlation beteen dissolved oxygen and inorganic phosphorus, dissolved oxygen and nitrites and the inorganic phosphorus and dissolved nitrite data from all the three localities were made use of.

Results and Discussions

The interrelationship of dissolved oxygen and inorganic phosphates, and dissolved oxygen and dissolved nitrites show inverse relation. But in case of distribution of inorganic phosphates and nitrites there is close parallelism between concentrations of these nutrients at all levels. Noble (1970) also opines that such inverse relation between dissolved oxygen and dissolved nutrients (phosphates and nitrites) is found to exist during the period of his study. It is of interest to note that nitrites showed their depletion during the post-monsoon period. Ramamurthy (1965) noticed total depletion of nitrites during August-September and remained so till November. Unlike nitrites phosphates did not suffer any depletion.

Variation of inorganic phosphorus, nitrites and dissolved oxygen

The variation of average phosphate content at surface, middle and bottom was from 0.22-1.35, 0.28-1.35 and 0.32-1.55 μg at/L. Similarly, the average values of dissolved oxygen fluctuated from 3.8-5.8, 1.1-5.8 and 0.67-7.7 ml/L respectively, in the depths stated above. The average nitrite values at surface, middle and bottom varied from 0.03-4.77, 0.04-5.46 and 0.13-4.87 μg at/L respectively.

The grand mean values arrived at surface, middle and bottom for 117 monthly average values at each level were 0.48, 0.53 and 0.63 μg at/L for inorganic phosphate 0.57, 0.86 and 1.14 μg at/L for dissolved nitrites and 4.38, 3.92 and 3.72 ml/L in the case of dissolved oxygen. A closer scrutiny of these values reveals that the dissolved oxygen content decreases from surface to the depths, while inorganic phosphorus and nitrites increase in their concentration from surface to the bottom (Figs. 1, 3).

Distribution of dissolved oxygen, percentage saturation and inorganic phosphorus

The values of dissolved inorganic phosphorus for eighty three monthly average ranged from 0.22-1.16 μg at/L at surface, 0.29-1.35 μg at/L at middle and 0.32-1.55 μg at/L at bottom in the bay waters and for the waters outside the bay they ranged from 0.27-1.35 μg at/L at surface, 0.28-1.19 μg at/L at the middle and 0.35-1.25 μg at/L at the bottom for thirty four monthly averages. The range of dissolved oxygen in the inshore bay was 3.46-5.55 ml/L,

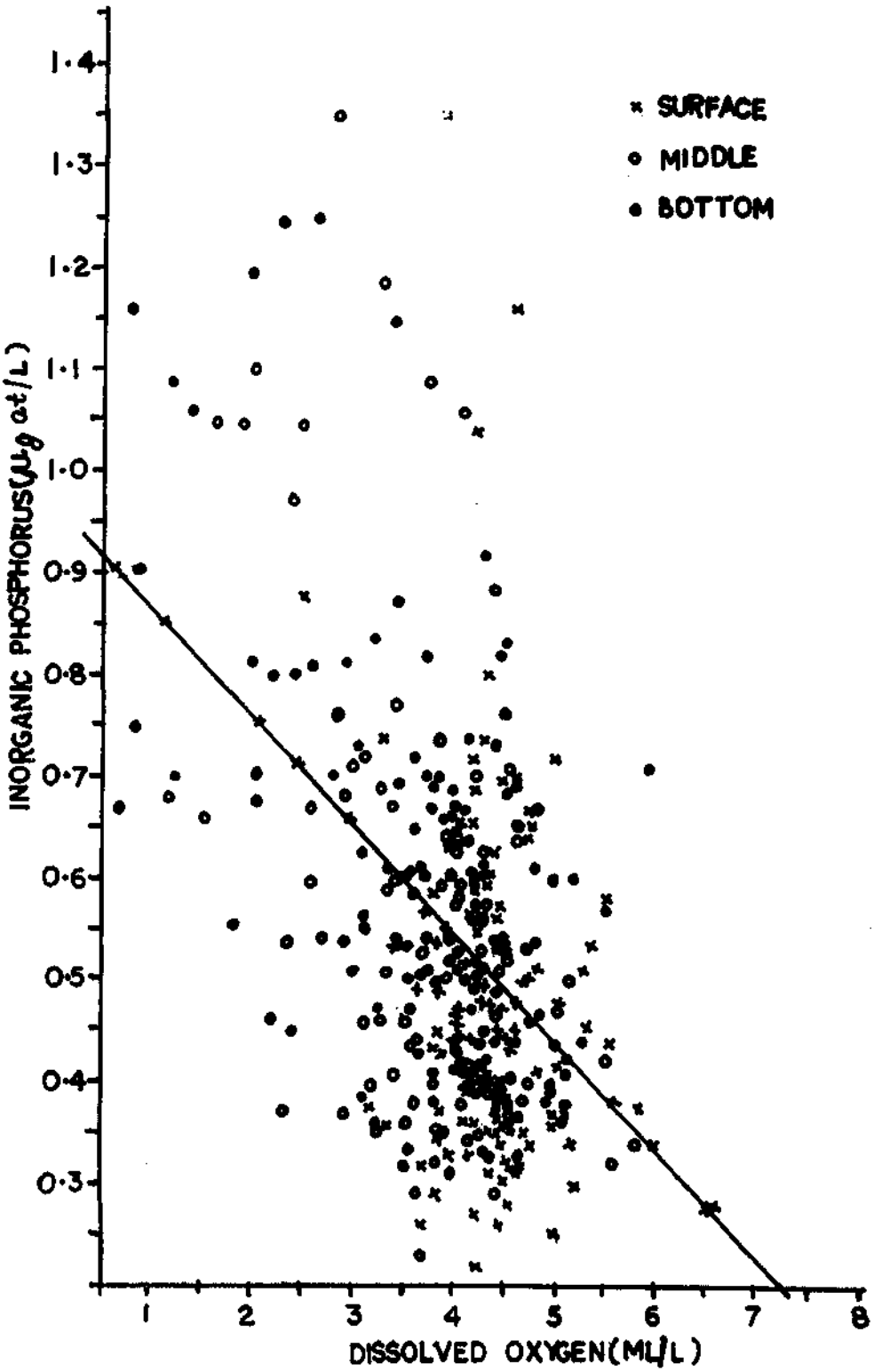

FIG. 1. Relation of dissolved oxygen and the inorganic phosphorus in the waters of Karwar.

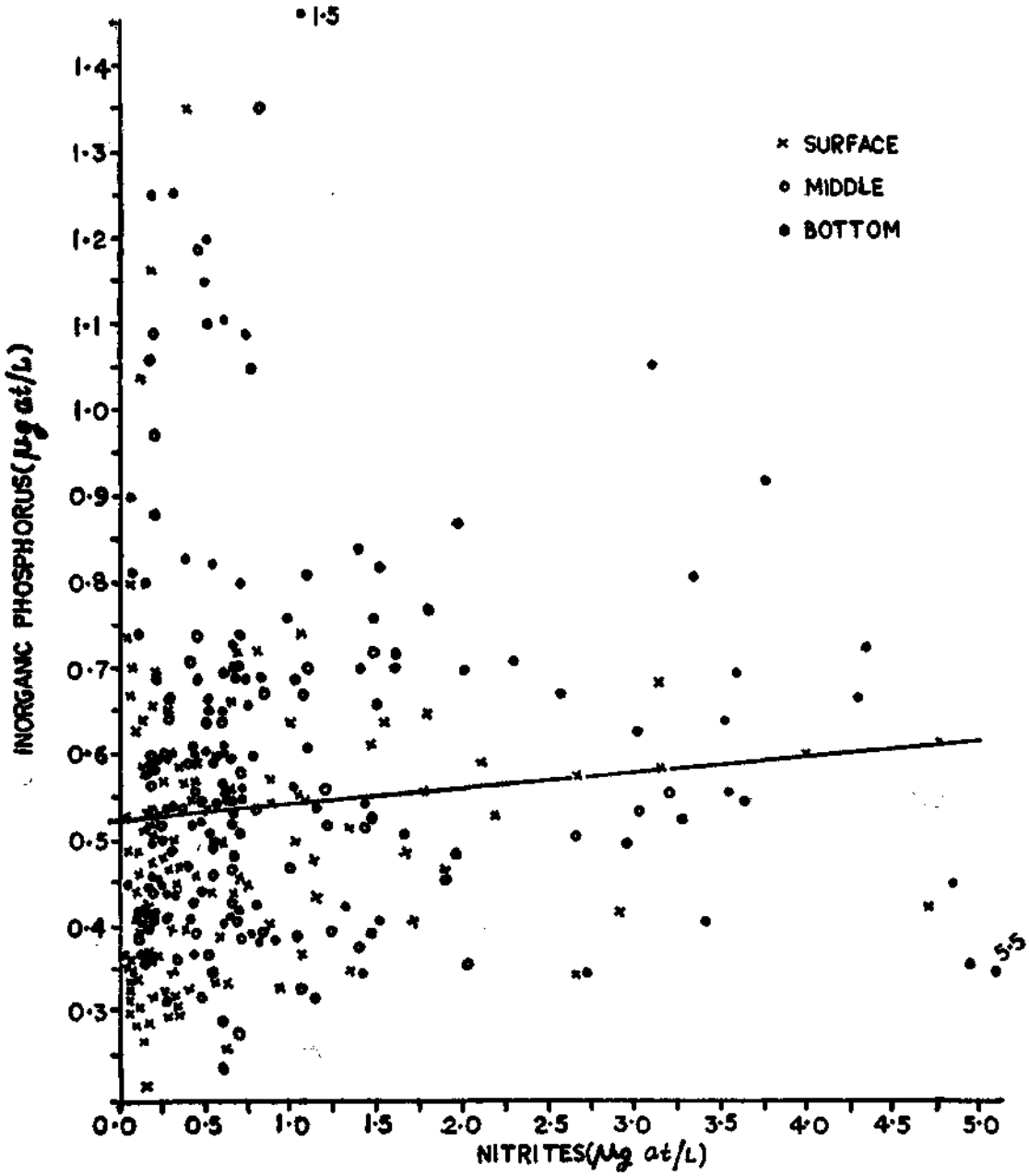

FIG. 2. Relation of dissolved nitrites and the inorganic phosphorus in the waters of Karwar.

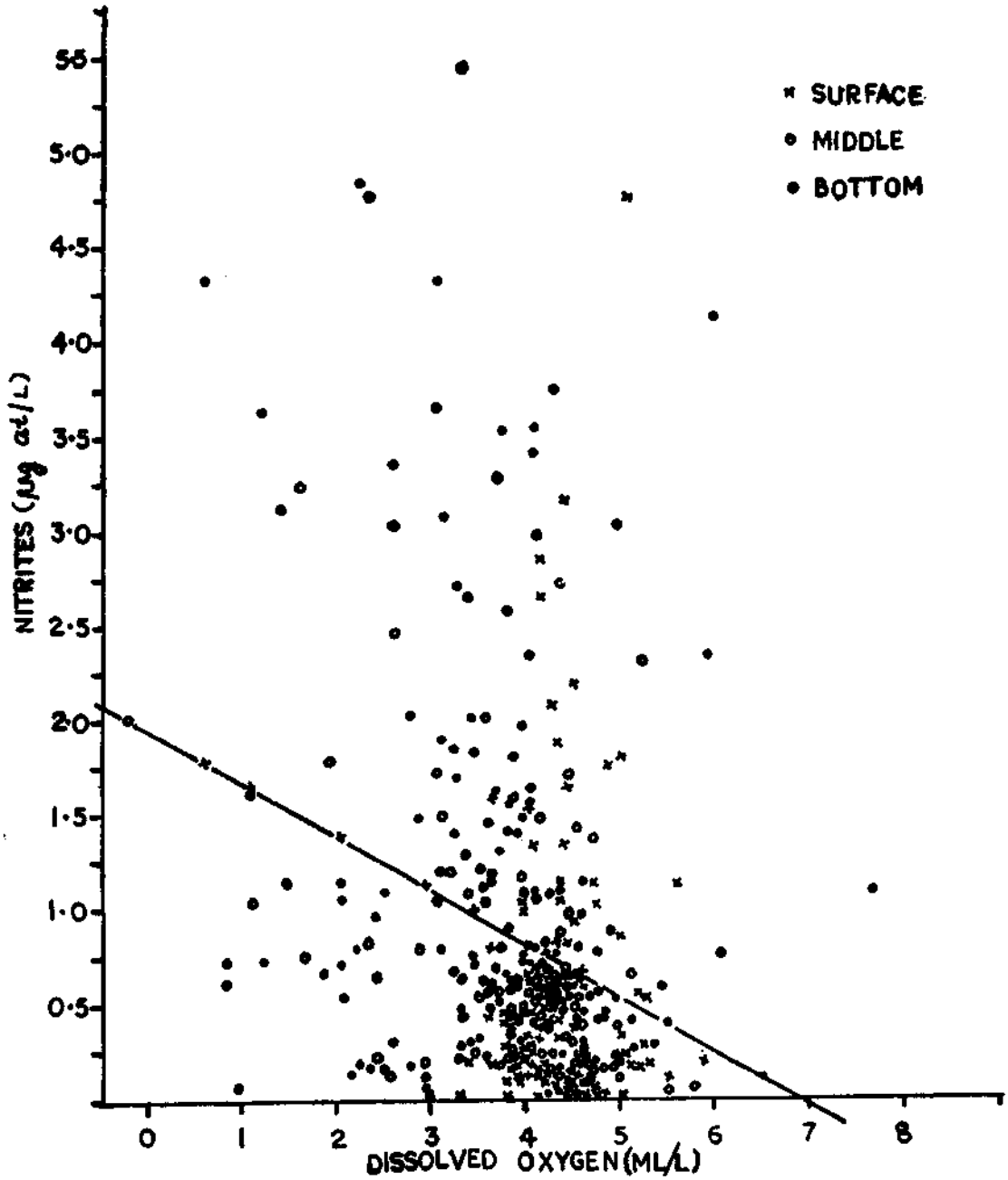

FIG. 3. Correlation of dissolved oxygen and nitrites in the waters of Karwar.

1.13-5.00 ml/L and 0.67-5.33 ml/L and that for the waters outside the bay was 3.69-5.77, 3.05-5.78 and 2.63-7.67 ml/L in the respective layers.

The distribution of dissolved oxygen also shows features of striking interest in both localities. In the inshore Bay, the surface waters always show rich oxygen distribution. The middle and bottom waters always show low oxygen content. This is more striking from June to September when the range of average is from 0.67-4.2 ml/L.

utilised for calculating percentage saturation at each level. In case of samples collected near Devgad Island and outside the Island out of 34 averages a single value at surface in February 1966 showed supersaturation (124.64%). But the middle and bottom values showed a number of supersaturations (10 values at middle and 16 at bottom) indicating higher photosynthetic activity in the depths (Fig. 4 a, b).

According to Subrahmanyan (1959) 'the demand on oxygen liberated during photosynthesis is so high as to leave back little to

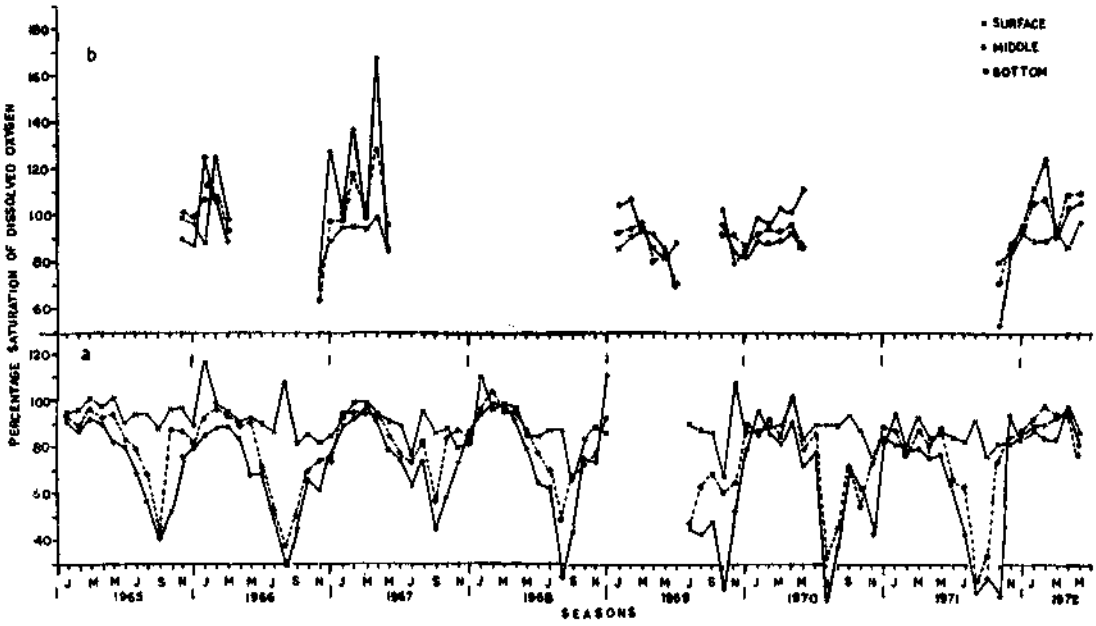

FIG. 4. Percentage saturation of dissolved oxygen in : a. Bay waters and b. water outside the bay.

The percentage saturation in the inshore waters indicated seven supersaturation values (100.35%, 101.3%, 116.22%, 108.67%, 110.03%, 106.89% and 100.18% in March 65, May 65, January 66, August 66, January 68, November '69 and May '69 respectively) in the surface waters and two in the middle 104.04%, 100.92% in February 1968 and May 1970) and only a single value (110.72% in December 1968) in the bottom layers, out of 83 monthly averages

raise the overall level of the concentration considerably towards the saturation or supersaturation level'. Stephenson (1949) also states that there is a close correlation between the reduction in oxygen concentration of the supernatant sea water and the rate of release of phosphate during regeneration from mud surface. Richards and Redfield (1954) also remarked that high organic content is equivalent to high oxygen demand. Ellis *et al.* (1946)

opined that many effluents, cannary refuse and paper mill wastes which contain substances which may be oxidised by the dissolved oxygen either directly or indirectly and collectively reduce the dissolved oxygen critically to low levels. In the present investigation, in the bay waters, the bottom waters may still show low oxygen content after interacting with the factors mentioned above. In the months of October to December also the subsurface waters showed low oxygen content. Most probably such factors may be acting in reducing the oxygen content of the area. The dissolved oxygen outside the bay did not show low oxygen in the depths. The data during monsoon and soon after was not available due to rain and inclement weather to study the distribution of dissolved oxygen in the waters outside the Bay.

Distribution of dissolved nitrites and inorganic phosphorus and their correlation

As stated already there is considerable similarity between the partners of distribution of phosphates and nitrites. The average nitrite values in the inshore bay at surface, middle and bottom varied from 0.03-4.77, 0.06-4.77 and 0.07-4.87 μg at/L respectively. Those in the outside bay waters fluctuated between 0.05 and 2.90 μg at/L, 0.04 and 5.46 μg at/L and 0.11 and 4.14 μg at/L at the same levels respectively.

In the present investigation even in the lower depth ranges from surface to 31 metres of coastal waters of Karwar, the concentration gradient of nutrients is very well exhibited in respect of both nitrites and inorganic phosphates.

It is found an indirect evidence that the growth rate of phytoplankton in nature is reduced when the concentration of these nutrients fall below the threshold values (Sverdrup *et al.*, 1942). Goldberg, Walker and Whisenand (1951) have shown the linear relation between the phosphorus content of cells of *Asterionella japonica* and to the concentration of orthophosphate in the external medium. According to Sverdrup *et al.* (1942) there is a close parallelism between the concentration of nitrite and phosphate ; this linear relationship represents the normal ratio of nitrogen to phosphorus of 15 : 1 atoms proposed by Cooper (1938). They have indicated the importance of this relationship for predicting with a fair degree of accuracy the concentration of either nitrate or phosphate when either one is known and a relationship exists between the concentrations of these elements and the oxygen depletion. By viewing the ratio of nitrogen to phosphorus in the light of Cooper's (1938), it was found that in the present investigation the ratio of nitrite to phosphorus for surface, middle and bottom waters is 1 : 18, 1 : 63 and 1 : 80 respectively.

It has been shown (Fig. 2) at Karwar also that it is found a linear relationship between nitrites and inorganic phosphorus.

The correlation coefficient (*r*)

For obtaining the correlation coefficient, the data for surface, middle and bottom was pooled and a common correlation coefficient was found out. The correlation coefficient between dissolved oxygen and inorganic phosphorus was 0.53, between dissolved oxygen and nitrites was 0.26. Both these values when tested were found to be significant at 5 and 1 per cent with 351 degrees of freedom. But the correlation coefficient(r) of 0.09 between dissolved nitrites and inorganic phosphorus when tested was found to be not significant at 5 and 1 per cent level. It is shown earlier that the relation between dissolved oxygen and the inorganic phosphorus is inverse. As the dissolved nitrites and the inorganic phosphorus bear linearity, the relation beween dissolved oxygen and nitrites is also inverse (Fig. 1 to 3).

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