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PHOSPHORUS FRACTIONS IN GULF OF MANNAR AND THEIR RELATION TO ORGANIC PRODUCTION

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ABSTRACT

The variations of the three phosphorus fractions—inorganic, organic and particulate P have been discussed in relation to the primary production in Gulf of Mannar off Mandapam. Though the rate of primary production is uniformly high, instantaneous concentration of inorganic P is low and without significant seasonal variation. But the total P, dissolved organic P and particulate P show definite seasonal variation. From primary production the rate of phosphate assimilation and regeneration have been deduced.

INTRODUCTION

PHOSPHORUS exists in sea water as dissolved inorganic phosphate, dissolved organic phosphorus compounds and particulate phosphorus as represented by plankton and detritus, as also by insoluble and adsorbed phosphates in suspension. Inorganic phosphate and total phosphorus determinations on a sea water sample before and after filtration will allow the estimation of the different fractions of phosphorus. Particulate phosphorus is found as the difference between the estimations of the ulfiltered and filtered samples and the dissolved organic phosphate as the difference between the values for the total filtered sample and for the inorganic fractions.

The work of Redfield *et al.* (1937) in the Gulf of Maine and of Armstrong and Harvey (1950) in the English Channel provide the basic information of the three fractions of phosphorus-containing materials in the sea.

In India investigations on the seasonal variations in the phosphate content of the coastal waters have been conducted by Jayaraman (1951) and Ramamurti (1953) at Madras, Jayaraman (1954) in Gulf of Mannar and Palk Bay, George (1953) and Subrahmanyan (1959) at Calicut and recently by Reddy and Sankaranarayanan (1968) for the shelf waters of the Arabian Sea. Besides, Seshappa and Jayaraman (1956) have studied the phosphates in the mud banks at Calicut and Qasim *et al.* (1969) in the Cochin Backwater. Extensive phosphate determinations over the Arabian Sea have been carried out during the IIOE recently ; even prior to this, DANA, DISCOVERY and GALATHEA Expeditions had measured the distribution of phosphates in the Indian Ocean (Clowes 1938 ; Steemann Nielsen and Jensen 1957). However, the pattern of the relative changes in the three fractions has not yet been studied.

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METHODS

As the greatest change in the three fractions of phosphorus takes place in the surface waters, samples collected from the surface in Gulf of Mannar during 1959-60 were analysed as part of the primary production studies (Prasad and Nair 1963). Duplicate samples of 'light' and 'dark' bottles were also analysed after a twenty-four-hour period *in situ* incubation. The method for the determination of inorganic phosphate was that of Robinson and Thompson (1948) and for total phosphorus perchloric acid digestion method of Hansen and Robinson (1953). The optical density was measured by a Hillger and Watts Spekker Absorptiometer with a red filter and the values were derived from calibration curves constructed with known standards. The results (monthly averages of 31 observations) are plotted in Figs. 1 and 2.

RESULTS AND DISCUSSION

The inorganic phosphate values were relatively low in the Gulf of Mannar and did not show much seasonal variation. The monthly average values varied from

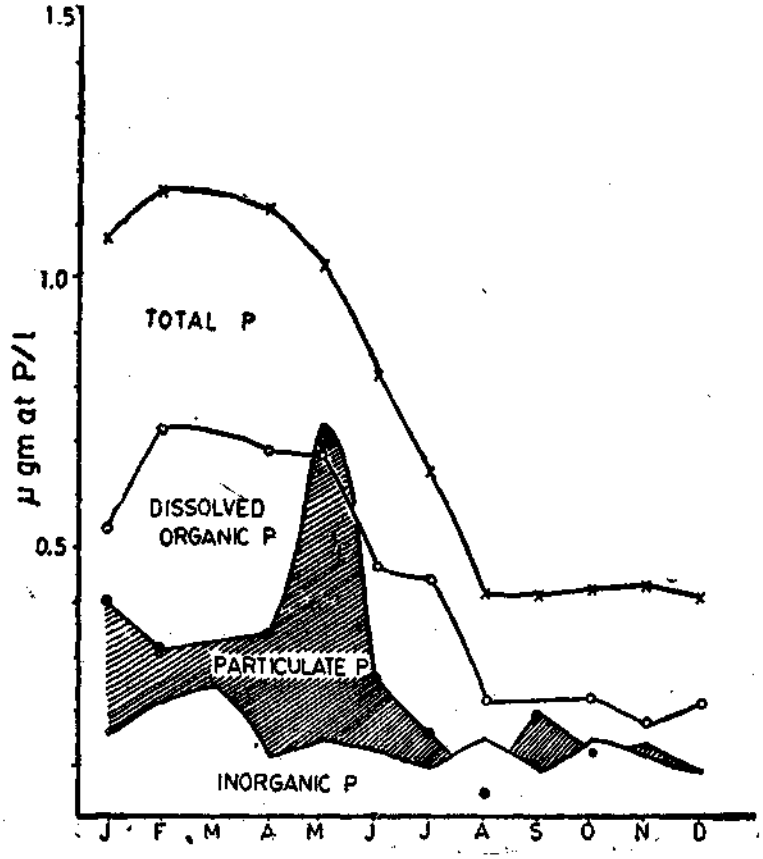

Fig. 1. Seasonal variation of phosphorus fractions in the surface waters of Gulf of Mannar (mean monthly values).

0.08 to 0.29 μg. at. P/l. The earlier investigations of Jayaraman (*loc. cit.*) also showed a similar pattern and magnitude. The peak value was seen in March with minor peaks in May, August and October. The total phosphorus, dissolved organic phosphate and particulate phosphorus, on the other hand, showed well-marked seasonal variation, though the magnitude of all the fractions was still of a lower order compared to that of the waters in the higher latitudes (Fig. 1).

The total phosphorus remained over 1.0 μg. at. P/l from January to May, between 0.5 and 1.0 μg at. P/l from May to July and at about 0.4 μg at. P/l for the rest of the year.

The same trend has been observed for the dissolved organic phosphate also which showed values > 0.5 μg. at. P/l between January and May. From August to December it remained at the lowest level of 0.2 μg. at. P/l. The bulk of the phosphorus content in the Gulf waters thus appears to be in dissolved organic form, the percentage distribution being over 50% on the average. It has been found to exceed 70% at times and only in one instance it had been reduced to less than 20%. Rao (1957) also has found that organic phosphorus formed 63-91.5% of the total phosphorus except in June when the south-west monsoon caused stirring up of sediment, which resulted in relatively less organic phosphate in solution.

The particulate phosphorus, the dominant fraction next to dissolved organic P, was available in varying proportions from January to July and September to November with the maximum values in May (*ca.* 0.85 μg. at. P/l). In fact, only during May the percentage contribution of particulate phosphorus as well as its magnitude exceeded that of the organic phosphorus fraction. This is presumably because of the high phytoplankton production (300-400 mg C/m^3/day in the surface waters) during this period. Because of the nature of sampling it is unlikely that zooplankton organisms would have contributed to this fraction. So it has to be assumed that the particulate phosphorus values obtained in this study were predominantly contributed by phytoplankton and to a lesser extent possibly also by detritus.

The inorganic fraction remains for the most part of the year at a low level of 12-15%. In March during the peak period it formed about 36%. The highest percentage contribution, however, was in August when it even formed 48% of the total at a time. The particulate phosphorus on that occasion was nil.

The trend for the three fractions is seen to persist in the 'light' and 'dark' bottles at the end of the experimental period of twenty-four hours when oxygen measurement was taken to estimate the gross primary production, except in March-April which is the period of zooplankton peak and excessive grazing of the phytoplankton. The 'dent' observed in the particulate fraction at this time (Fig. 2) could probably be the effect of grazing of the enclosed population. At all other times a consistent increase of phytoplankton cells was observed in the light bottles which accounts for the increase in the particulate fraction as compared to that of the dissolved organic fraction.

While discussing the comparatively lower level of phosphate in the Gulf of Mannar combined with the absence of marked seasonal cycles, Jayaraman (1964) had speculated whether this could too indicate a low level of organic production in these waters. However, he had also stressed the contention of Delsman (1939) that probably the more rapid metabolism in the tropical seas would check such an accumulation of nutrients as usually occurs in most northern waters during the winter.

A high rate of photosynthesis in the surface water all through the year requires a considerable amount of nutrients. As shown by Ketchum (1947), it is the

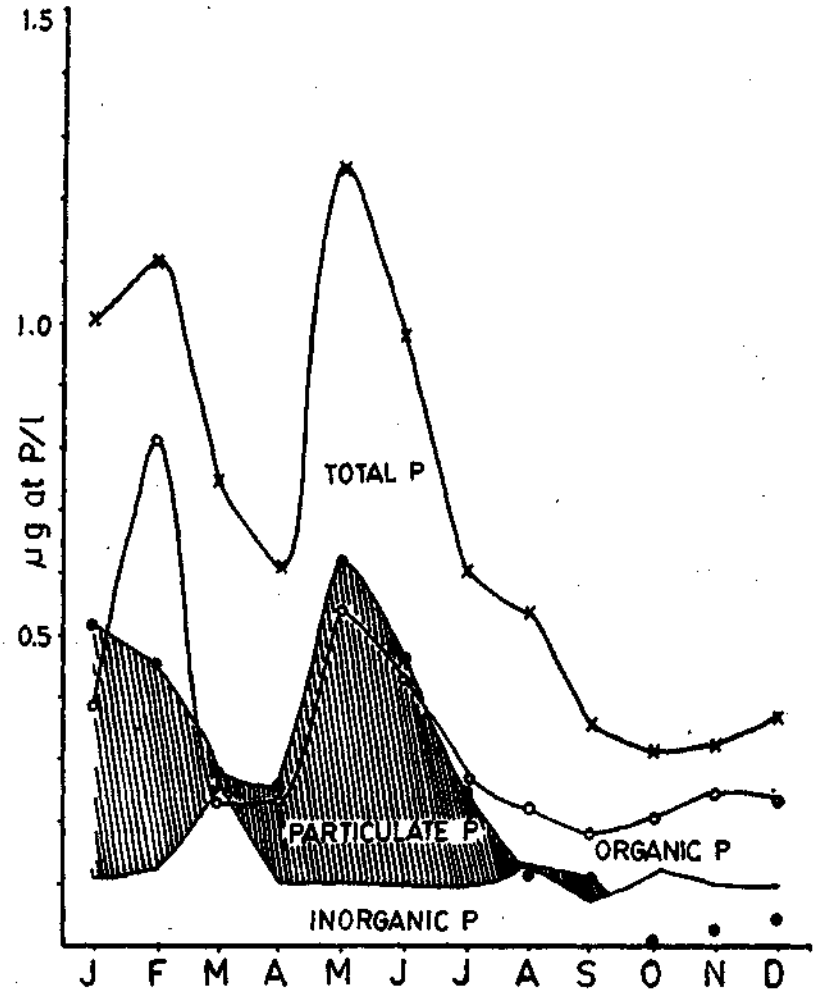

Fig. 2. Phosphorus fractions in the light bottle after 24 hours' incubation (mean monthly values).

replenishment and not the instantaneous concentration which determines the fertility of an aquatic environment.

The regeneration of phosphate could be measured indirectly i.e., roughly 1 mgP is assimilated for every 40-50 mgC (Steemann Nielsen and Jensen, 1957). The values of organic production at this station for the period varied between 124 mgC/m^3/day in July to 388 mgC/m^3/day in April with an annual mean of 202 mgC/m^3/day (Prasad and Nair, 1963). Hence, the daily phosphate assimilation may be assumed to be about 4 mg/m^3/day (0.13 µg. at. P/l) which is about the average quantity

available in solution in the surface waters. The inorganic phosphate in solution at any moment in a water mass may represent from 1 to 500 per cent of the amount taking part in the daily metabolism (Steemann Nielsen, 1951). Cushing (1971) has recently pointed out that the quantity of nutrients in the sea may depend upon the production and not the other way round, as has been suggested.

It may thus be seen that the amount of phosphate assimilation in the shallow waters of the Gulf of Mannar is almost cent per cent of the inorganic phosphate that is present in solution. As the water masses are without stratification throughout the year and are in constant contact with the bottom, the regeneration of phosphate taking place at the bottom is constantly utilised by the phytoplankton at almost the same rate. The speed of regeneration from the shallow bottom seems to be high enough to maintain the phosphate almost at a constant level.

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