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# Photosynthetic values and inorganic nutrient contents of Sungai Ibai, Trengganu.

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**Key words: Phtosynthetic values; inorganic nutrients.**

## RINGKASAN

*Penyukatan kadar fotosintesis dan kandungan nutrien bagi sampel-sampel bawah permukaan air dari empat stesyen penyelidikan di Sungai Ibai di Trengganu menunjukkan bahawa di musim tengkujuh berlaku penurunan kadar fotosintesis, manakala menghasilkan peninggian kandungan nitrogen ammonia, nitrogen nitrat dan larutan oksigen. Satu variasi musimam bagi nilai bersih fotosintesis telah dapat dilihat, di mana kadar yang tinggi wujud di musim kering dan kadar yang rendah wujud di musim basah. Walau bagaimanapun, kandungan nitrogen ammonia melebihi kandungan nitrogen nitrat dan phophorus reaktif sepanjang tahun. Terjadinya ketinggian kandungan nitrogen nitrat adalah disebabkan oleh ketinggian proses nitrifikasi, manakala ketinggian kandungan nitrogen ammonia disebabkan oleh ketinggian proses mineralisasi atau pereputan.*

## SUMMARY

*Photosynthetic rates and nutrient content measurements of subsurface water samples at four predetermined stations of Sungai Ibai in Trengganu indicated that the wet monsoon period lowers the values of the former while increasing the ammonium nitrogen, nitrate nitrogen and dissolved oxygen contents. A seasonal variation in net photosynthetic values is observed, being high during the dry season and low during the wet monsoon season. However the ammonium nitrogen content exceeds that of either nitrate nitrogen or reactive phosphorus the whole year through. In relation, the nitrite nitrogen content is insignificant. The occurrence of high nitrate nitrogen contents could be attributed to increased nitrification processes while that of ammonium nitrogen to bacterial mineralization or decomposition.*

## INTRODUCTION

There are few studies on photosynthetic rate measurements or other related fields in a tropical aquatic environment, especially estuarine or brackish water which acts as a nutrient trap or sink. Many Malaysian rivers have been reported to be polluted by agro-based industrial effluents, untreated human and animal wastes, and siltation due to erosion from land developments (Bishop, 1973; Law *et al.*, 1980; Ho, 1973; Law, 1980). Unfortunately these investigations were not related to the primary productivity of the system.

A detailed study of the net photosynthetic values, the nutrient contents and other biological, chemical and physical parameters of the Sungai Ibai in Kuala Trengganu was undertaken. The influence of the North East Monsoon (from November to February) and the South West Monsoon (from March to August) seasons, which cover the rainy and dry periods respectively, on the photosynthetic rate at various stations was studied.

## METHODS

The research was carried out in Sungai Ibai, Trengganu, between mid January and late December 1980 at four stations, viz. $I_1$, $I_2$, $I_3$, and $I_4$ respectively, located 1 mile from each other (Fig. 1). Subsurface samples were taken from all the stations and attempts were made to perform depth profile studies of productivity rates and nutrients at stations $I_1$ and $I_3$ during high tide around late" December. The subsurface samples were taken in carboys immediately to the laboratory for analysis. Photosynthetic values ($\mu$g. C/l/h) of the samples were determined on incubation of 125 ml sampling bottles either in the dark or light (40,000 lux) over a period of three to four hours at a constant temperature of 25° C.

**Key to authors' names: L. Shamsudin and U. Salleh.**

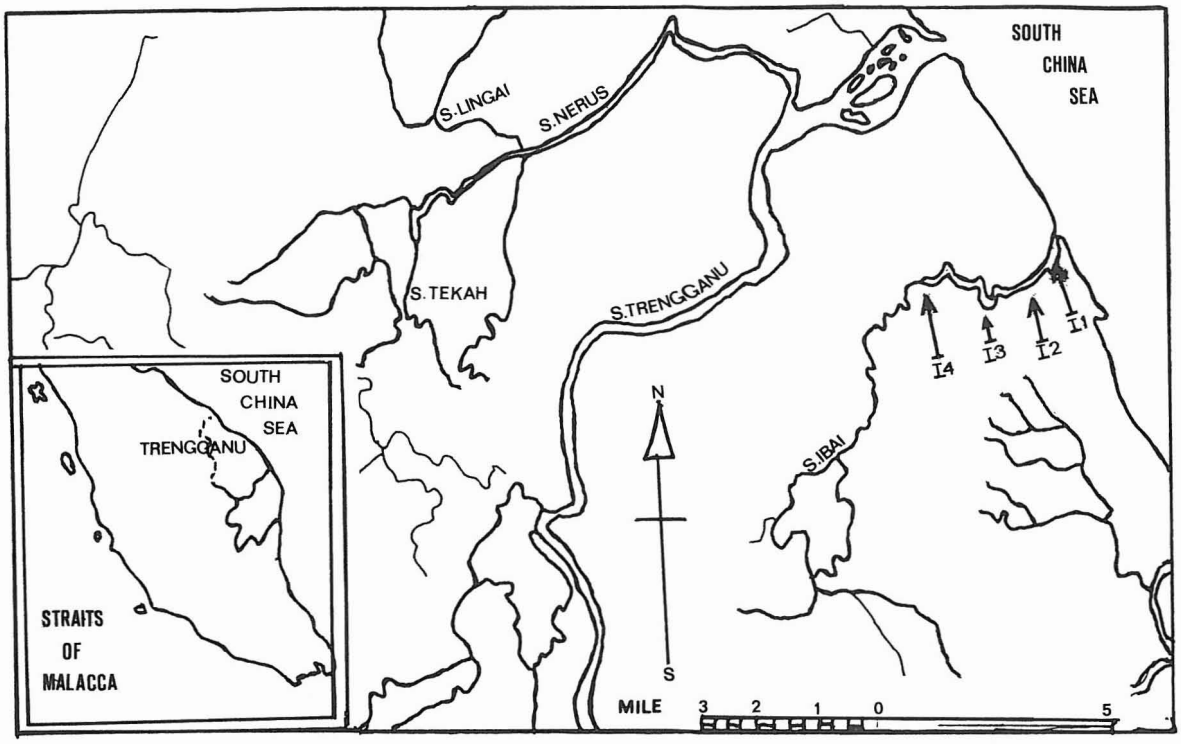


*Fig. 1. Map showing sampling stations along Sungai Ibai, Trengganu.*

Photosynthetic oxygen measurements were carried out according to the method of Bryan, Riley and William (1976). This method has a Winkler titration coefficient variation of 0.1%. Sampling bottles were filled by siphon, allowing at least the volume of the bottle to overflow before the bottles were stoppered. The Winkler reagents of 3 N $MnCl_2$ and 4 M NaI in 8 N NaoH (1 ml. each) were added to the sample and a precipitate of manganese hydroxide was formed. After the precipitate had settled at the bottom of the bottle, 1 ml of N $H_2SO_4$ was then added. When the precipitate had dissolved, it was then titrated against standard 0.5 N thiosulphate according to the method of Bryan *et al.*, (1976). The titration end point was detected by a photocell sensor with the aid of an electrical plotter. The thiosulphate solution was standardised against 0.0 IN iodate.

Determination of ammonium was carried out by the Shamsudin (1979) modified method of Solorzano's (1969) in order to eliminate the high blank values, which basically is a colorimetric phenolhypochlorite method. Nitrate nitrogen was determined by the colorimetric cadmium copper amalgam reduction method (Strickland and Parsons, 1972) while the determination reactive phosphorus was carried out by the colorimetric ascorbic molybdate method (Strickland and Parson, 1972). Salinity, conductivity and temperature at the various sampling stations were measured with a SCT meter.

## RESULTS

High net photosynthetic values were observable at the stations throughout the dry periods especially between April and September (Fig. 2). The net photosynthetic values ranged between 64.5-95.4, 69.2-98.4, 52.4-85.3 and 40.4-65.2 $\mu$g. C/l/h at stations $I_1$, $I_2$, $I_3$, and $I_4$ respectively. Station $I_1$, situated near the river mouth, had the highest photosynthetic values especially between May and September.

High concentrations of ammonium nitrogen were present at all stations especially between May and October. These ranged between 6.1-10.9; 5.5-10.2; 4.3-6.9 and 3.0-6.5 $\mu$g. at $NH_4^+$-N/l at stations $I_1$, $I_2$, $I_3$ and $I_4$ respectively. However, the values were significantly higher during the dry periods at all stations. Nitrate nitrogen was lower than ammonium nitrogen at all stations the whole

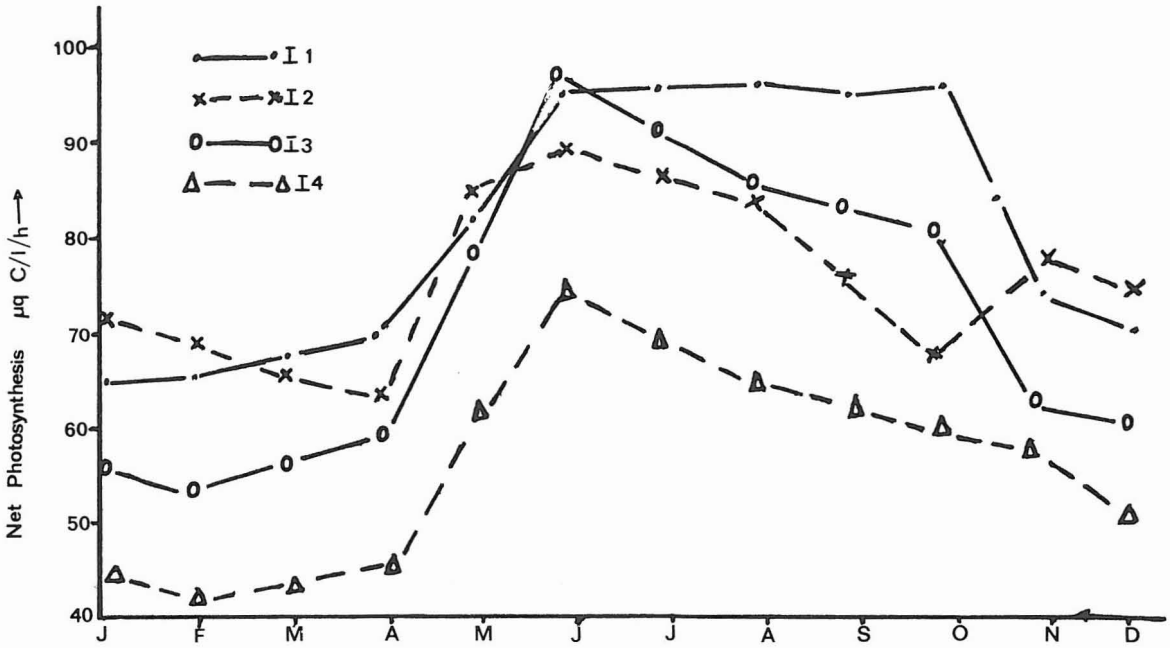


*Fig. 2. Monthly net photosynthetic values in µg C/l/h for various stations along Sungai Ibai*

year through (*Figs. 3* and *4*). The nitrate nitrogen contents ranged between 1.4-2.3; 1.4-2.3; 0.9-2.1 and 1.3-1.7 µg. at $NO_3^-$-N/l at stations $I_1$, $I_2$, $I_3$ and $I_4$ respectively, and their contents were comparatively higher during the wet Monsoon season while ammonium contents were comparatively lower. In this regard, nitrite nitrogen contents at all stations were found to be insignificant (0.009 µg. at $NO_2^-$-N/l).

Reactive phosphorus contents ranged between 2.1-5.1; 2.3-4.9; 1.9-3.8; and 1.3-1.7 µg. at. P/l at stations $I_1$, $I_2$, $I_3$ and $I_4$ respectively. Relatively high reactive phosphorus content was observed during the wet periods and vice versa during the dry periods *(Fig. 5)* indicating similarity to that of nitrate nitrogen contents. Further, high dissolved oxygen contents were also observed during the wet monsoon periods at all stations *(Fig. 6)*.

Surface temperature and pH values were relatively constant at all stations throughout the study period (Tables 1.1-1.4). The salinity ranged between 10-22; 5-18; 2.5-10 and 0-0.5 ppt at stations $I_1$, $I_2$, $I_3$ and $I_4$ respectively (Table 1.1-1.4). Generally, the salinity was lower during the wet monsoon periods and higher during the dry periods. However, it should be noted that salinity at station $I_4$ approached that of fresh water throughout the study period.

Study of the depth profile of net photosynthetic values at stations $I_1$, and $I_3$ (i.e. at high tide in late December) demonstrated a decrease in net photosynthetic values from mid water (1 meter deep) to deep water *(Fig. 7)* at both stations. However, the subsurface waters (*ca* 0.3 m deep had a lower net photosynthetic value than that of the mid water layer at both stations. The depth profiles for other parameters, viz. ammonium nitrogen, nitrate nitrogen, reactive phosphorus, pH and salinity, did not show any significant variation in values. (Tables 2.1 – 2.2).

## DISCUSSION

It is obvious from the investigation that a seasonal variation in net photosynthetic values exists in Sungai Ibai. Further, profile studies evidently indicate a decrease in net photosynthetic values from the mid water column (1 m deep) to deeper water, i.e. the subsurface water (*ca* 0.3 m deep) has a lower net photosynthetic value than that of the mid water layer. This phenomenon could be attributed to the inpenetrability of radiant energy and the prevailing dilution and siltation effects of the South West Monsoon season (November to February) resulting in reduced rates in photosynthetic values with depth. The same argument holds for the relatively lower concentration in ammonium nitrogen contents at all

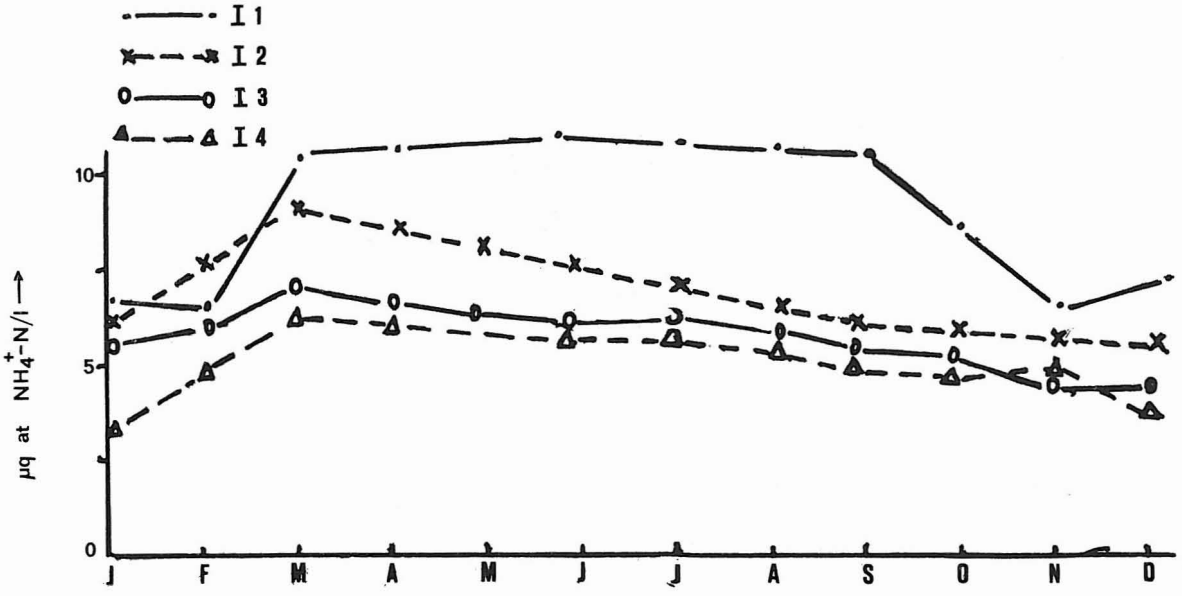


*Fig. 3. Monthly ammonium nitrogen contents in μg at $NH_4^+$-N/l for various stations along Sungai Ibai.*

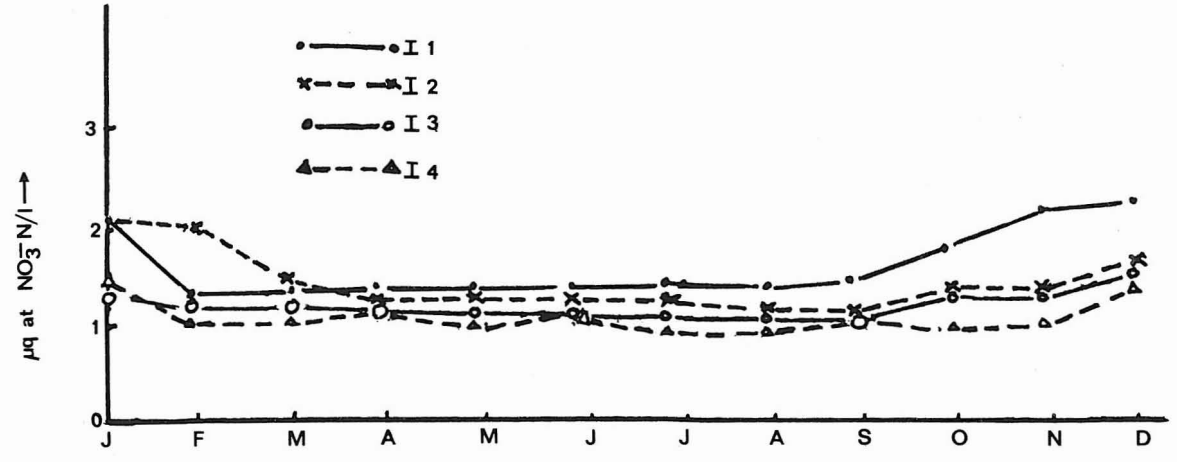


*Fig. 4. Monthly nitrate nitrogen contents in μg at $NO_3^-$-N/l for various stations along Sungai Ibai.*

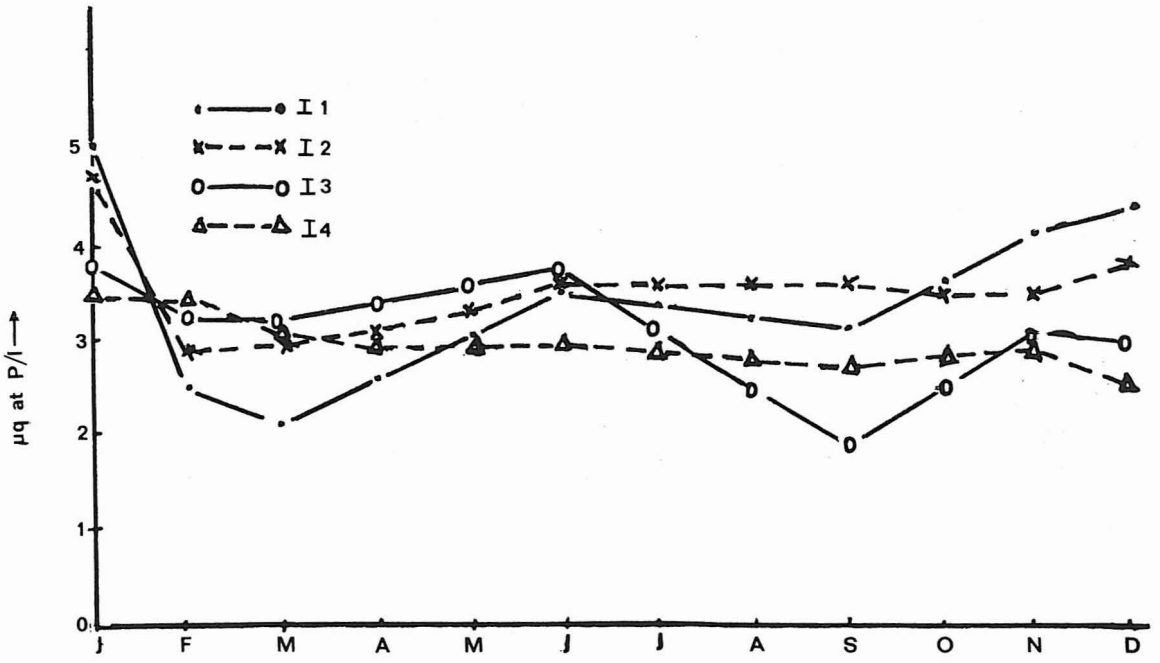


*Fig. 5. Monthly reactive phosphorus µg at P/l for various stations along Sungai Ibai.*

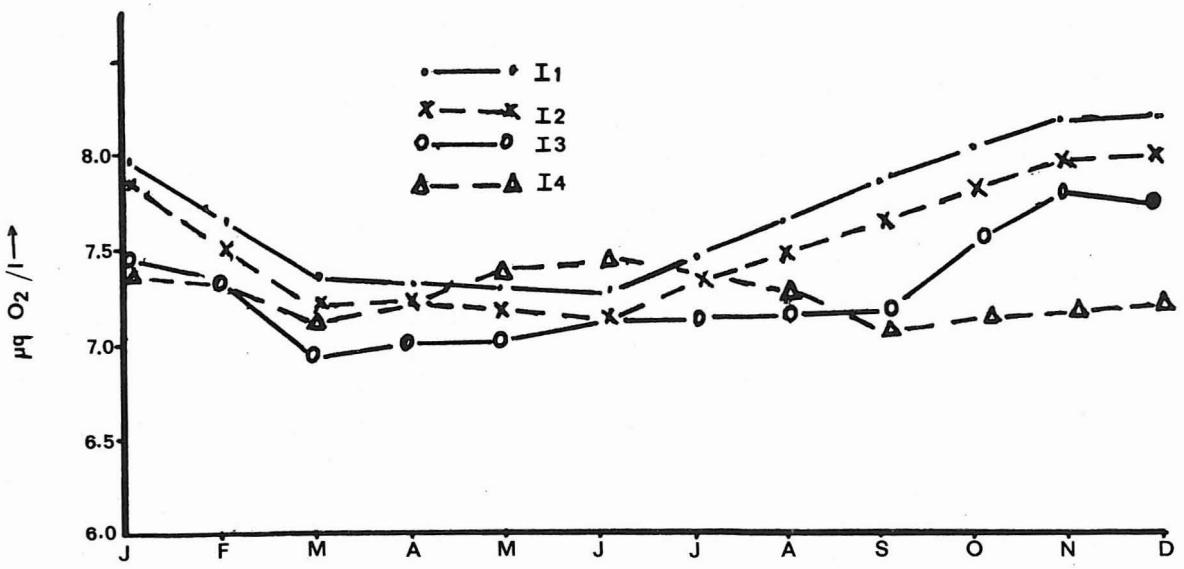


*Fig. 6. Monthly dissolved oxygen values in mg $0_2$/l for various stations along Sungai Ibai.*

TABLE 1
Surface temperature, pH and salinity values for stations $I_1$, $I_2$, $I_3$ and $I_4$

Table 1.1 : Station $I_1$

| Date: Year 1980 | 27/1 | 10/2 | 13/3 | 15/4 | 14/5 | 12/6 | 12/7 | 13/8 | 15/9 | 17/10 | 20/11 | 14/12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface Temp. °C | 25 | 25 | 29 | 28 | 27 | 27 | 28 | 29 | 27 | 26 | 25 | 25 |
| pH | 7.2 | 7.3 | 7.5 | 7.3 | 7.2 | 7.8 | 7.4 | 7.5 | 7.4 | 7.2 | 7.1 | 7.1 |
| Salinity p.p.t. | 11 | 12 | 18 | 15 | 15 | 15 | 20 | 22 | 18 | 12 | 10 | 9.5 |

Table 1.2 : Station $I_2$

| Date: Year 1980 | 27/1 | 10/2 | 13/3 | 15/4 | 14/5 | 12/6 | 12/7 | 13/8 | 15/9 | 17/10 | 20/11 | 14/12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface Temp. °C | 25 | 26 | 27 | 29 | 29 | 28 | 27 | 26 | 26 | 25 | 25 | 25 |
| pH | 7.4 | 7.3 | 7.0 | 7.0 | 7.0 | 7.1 | 7.2 | 7.1 | 7.4 | 7.3 | 7.4 | 7.5 |
| Salinity p.p.t. | 5 | 8 | 15 | 16 | 15 | 15 | 17 | 18 | 15 | 7.5 | 5.5 | 5.5 |

Table 1.3 : Station $I_3$

| Date: Year 1980 | 27/1 | 10/2 | 13/3 | 15/4 | 14/5 | 12/6 | 12/7 | 13/8 | 15/9 | 17/10 | 20/11 | 14/12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface Temp. °C | 25 | 26 | 27 | 28 | 29 | 28 | 27 | 26 | 26 | 25 | 25 | 25 |
| pH | 7.4 | 7.3 | 7.1 | 7.0 | 7.1 | 7.0 | 7.2 | 7.3 | 7.4 | 7.3 | 7.4 | 7.3 |
| Salinity p.p.t. | 5 | 6 | 8 | 8 | 9 | 10 | 10 | 10 | 5.0 | 2.5 | 2.5 | 2.5 |

Table 1.4 : Station $I_4$

| Date: Year 1980 | 27/1 | 10/2 | 13/3 | 15/4 | 14/5 | 12/6 | 12/7 | 13/8 | 15/9 | 17/10 | 20/11 | 14/12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface Temp. °C | 25 | 27 | 26 | 27 | 29 | 29 | 28 | 26 | 27 | 25 | 25 | 25 |
| pH | 7.4 | 7.3 | 7.0 | 7.0 | 7.0 | 7.1 | 7.0 | 7.0 | 7.1 | 7.5 | 7.4 | 7.3 |
| Salinity p.p.t. | 0.5 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

stations throughout the South West Monsoon season.

It is suggested that the increased dissolved oxygen content during the wet monsoon period, enhances the biodegradation of nitrogenous organic matter, and facilitates the oxidation of ammonium by nitrification bacteria. The increased nitrate content in the river could also be due to the leaching processes of fertilisers from adjacent agricultural land as the banks of Sungai Ibai are intensively exploited for paddy cultivation and other agricultural activities.

It has been observed that station $I_1$, situated near the river mouth, contained relatively high concentrations of inorganic nutrients (especially ammonium) when compared to the other stations upstream. This would be the reason for a high photosynthetic value in such an aquatic system. It is also very interesting to note that in all the sampling stations, the ammonium content exceeded that of nitrate. In contrast, Raine (1973) working on a temperate estuary found the indigenous content of nitrate to be much higher than that of ammonium by a factor of 5 (i.e., indigenous nitrate as 20 $\mu$g. at N/l and that of ammonium as 4.5 $\mu$g.

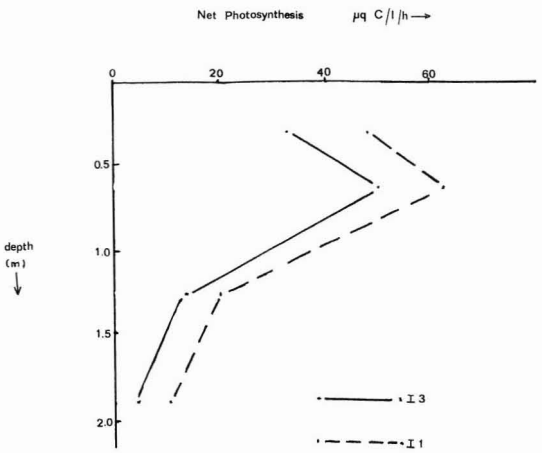


*Fig. 7. Net photosynthetic values in μg C/l/h versus depth for stations $I_1$ and $I_3$ taken during high tide.*

at. N/l). Comparing the photosynthetic values obtained by Raine (1972) and the those obtained in the present study, it would appear that the temperate estuary is more productive than the tropical one. Studies by Beinfang (1975) suggested that in temperate water, the uptake nitrogen source by phytoplankton was competitive. Antia *et al.*, (1963) using algal populations in large volume plastic sphere, found that the uptake of nitrogen source was also competitive.

It has been observed that during the dry season dissolved oxygen and nitrate nitrogen contents dropped considerably while ammonium nitrogen contents rose at all stations. This was probably due to the decreased activities of the nitrification bacteria in the system culminating in the accumulation of ammonium derived from microbial organic nitrogen mineralisation or decomposition. The presence of higher level reactive phosphorus at all stations throughout the wet monsoon period could be attributed also to the leaching process of fertilisers from the surrounding agricultural land. Throughout the study period, nitrate nitrogen contents in any one of the stations were relatively lower than those of either ammonium nitrogen or reactive phosphorus, reflecting a rapid mineralisation or decomposition process.

## SUMMARY

a) The ammonium nitrogen content in all stations exceeded that of either nitrate

TABLE 2

Depth profile values in net photosynthetic and other chemical parameters at station $I_1$, and $I_3$ taken during high tide

Table 2.1 : Station $I_1$

| Depth (m) | Net PS μg C/ l/h | $NH_4^+$ μg at N/l | $NO_3^-$ μg at N/l | P μg at p/l | S°/00 p.p.t. | pH |
|---|---|---|---|---|---|---|
| 0.3 | 45 | 5.8 | 2.1 | 3.5 | 10 | 7.0 |
| 0.7 | 62 | 6.2 | 2.3 | 4.0 | 11 | 7.0 |
| 1.2 | 21 | 4.9 | 1.7 | 3.2 | 8 | 6.8 |
| 1.6 | 11 | 5.1 | 1.9 | 3.9 | 8 | 7.0 |

Table 2.2 : Station $I_3$

| Depth (m) | Net PS μg C/ l/h | $NH_4^+$ μg at N/l | $NO_3^-$ μg at N/l | P μg at p/l | S°/00 p.p.t. | pH |
|---|---|---|---|---|---|---|
| 0.3 | 33 | 6.0 | 1.6 | 2.8 | 2.0 | 7.0 |
| 0.7 | 50 | 6.5 | 1.8 | 3.0 | 2.5 | 6.8 |
| 1.2 | 12 | 6.4 | 1.4 | 3.0 | 2.0 | 7.0 |
| 1.6 | 5 | 6.7 | 1.8 | 3.2 | 2.0 | 7.0 |

Note: PS – Photosynthesis, P – Phosphorus, S – Salinity.

nitrogen or reactive phosphorus throughout the study period. However, nitrite nitrogen contents were found to be insignificant.

b) Station $I_1$, situated near the river mouth, received large quantities of inorganic nutrients (such as, ammonium nitrogen, nitrate nitrogen or reactive phosphorus) from upstream. As such relatively high net photosynthetic values were obtained.

c) In all sampling stations, there was a seasonal variation in net photosynthetic values, being high during the dry season and low during the wet monsoon season throughout the study period.

d) The occurrence of high concentrations of nitrate nitrogen could be an indication of an increased rate of nitrification process by bacterial mineralisation or decomposition.

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