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# Seasonal variation in primary production in relation to some limnological features in Lakhotia lake (India)

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**Abstract.** The primary production of lake Lakhotia in the semiarid region of Rajasthan, India is reported. The results are compared with other tropical and temperate water bodies. Primary production revealed positive relationship between water temperature and chlorophyll-a. High production was observed when temperatures ranged from 27–33° C.

**Keywords.** Primary production; temperature; transparency; alkalinity; chlorophyll-a.

## 1. Introduction

In order to exploit freshwater resources like ponds, reservoirs and lakes for substantial pisciculture fundamentally, the primary production of these waterbodies has to be assessed. Except for the contribution of Sreenivasan (1963, 1964, 1965, 1976), Hussainy (1967), Ganapati and Pathak (1969), Sumitra (1971) and Bohra (1976), our knowledge of the primary productivity of the tropical freshwaters of India is meagre when compared to that for the temperate waters. Therefore intensive studies on the primary production in India are indispensable for the planned utilization of water resources. Hence, an attempt was made to know the primary production in Lakhotia lake located at Pali and the results compared with other available tropical and temperate freshwaters.

## 2. Study area

Pali district comes in the western region of Rajasthan. Its climate is characterised by extremes of temperature and aridity. The following three main seasons are noticeable in the state. Summer from March–June, monsoon from July–October, winter from November–February. Lakhotia is a man-made, rain-fed, perennial lake of Pali city (25·8° N Lat. and 73·3° E Long.). It is roughly oval-shaped (maximum length 1825 m in the east-west direction and breadth of 950 m in north-south direction) and has a maximum depth of 4.5 m. There were no rooted, emerged or submerged vegetation in the littoral zone of the lake. Details of study area are given by Khatri (1984).

## 3. Methods

Seasonal study of various abiotic and biotic factors related to primary production was conducted for 15 months from December 1976 through February 1978. The data from

December 1976 through February 1977 are exploratory in nature and are therefore not considered. The sampling was done in the last week of each month and the sampling hours and incubation period were kept constant throughout the observation period from 1000–1200 hr and 1200–1600 hr respectively. Three stations (sts. 1, 2 and 3) along the midlongitudinal area of the lake, equidistant from each other, and three depths (surface, 1 m and bottom) were selected to get a complete picture of the lake along its horizontal as well as vertical profiles. The surface and sub-surface water temperatures were recorded with mercury thermometer. Transparency was measured by a standard sechi disc (20 cm diameter) and alkalinity by titration method in field, using phenolphthalein and methyl orange as indicators. Chlorophyll-a was estimated using the method of Strickland and Parsons (1972). Light and dark bottle method was used for measuring primary production *in situ*, using modified Winkler's method (Strickland and Parsons 1972) for estimating dissolved oxygen. The oxygen values were then computed to carbon values using a photoperiod of 12 hr.

## 4. Results

There is no significant difference between the results at the three stations at the 3 different depths, therefore the mean of the three stations is taken.

The water temperature showed a wide range of seasonal fluctuations and decreased with depth. It ranged from 17·9–33·0° C at the surface, 17·8–31·6° C at 1 m depth 17·5–31·1° C at the bottom (figure 1).

Chlorophyll-a showed three maxima, the first in summer (June), the second in monsoon (October) and the third in winter (January). Out of these three peaks the maximum concentration was in June, and the minimum in April at the surface while it was minimum at 1 m depth and bottom in February. The values fluctuated from 1·228–6·959 mg $m^{-3}$ at the surface, 1·015–7·426 mg $m^{-3}$ at 1 m and 0·532–7·408 mg $m^{-3}$ at the bottom (figure 2).

Gross primary production increased from April onwards, attaining its peak in June at the surface and 1 m, which coincides with the summer peaks of chlorophyll-a. The

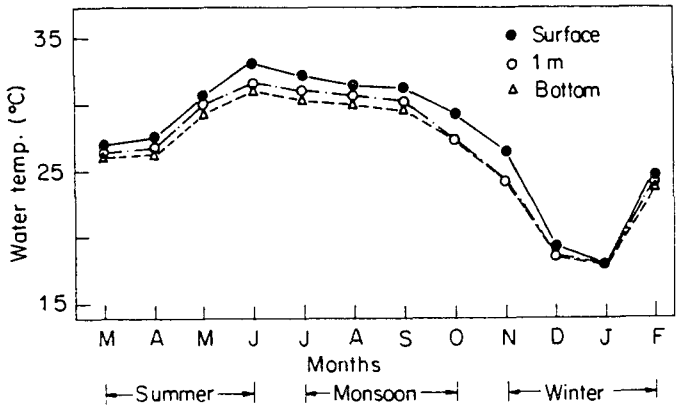


**Figure 1.** Seasonal variation in water temperature in Lakhotia lake.

values ranged from 1·002–6·301 gC $m^{-3}d^{-1}$ at the surface, 0·375–4·776 gC $m^{-3}d^{-1}$ at 1 m and 0–1·744 gC $m^{-3}d^{-1}$ at the bottom (figure 3). There was no production at the bottom in June and October when chlorophyll-a was high. This might be due to the low transparency which caused incidence of light attenuated below at the bottom during the above months.

The net primary production fluctuated from 0·062–2·977 gC $m^{-3}d^{-1}$ at the surface, 0–2·068 gC $m^{-3}d^{-1}$ at 1 m and 0–0·625 gC $m^{-3}d^{-1}$ at the bottom (figure 4).

The inter-relationship between gross primary production, chlorophyll-a, temperature, transparency and alkalinity at surface, 1 m and bottom were studied. These parameters were the same at all depths, therefore only the surface graphs are given in the text (figure 5).

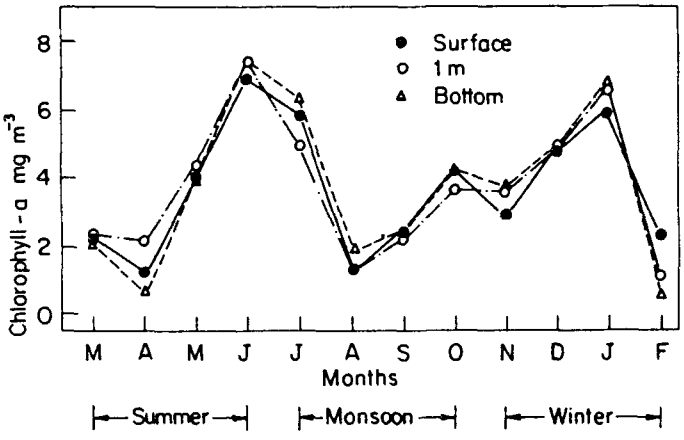


**Figure 2.** Seasonal variation in chlorophyll-a in Lakhotia lake.

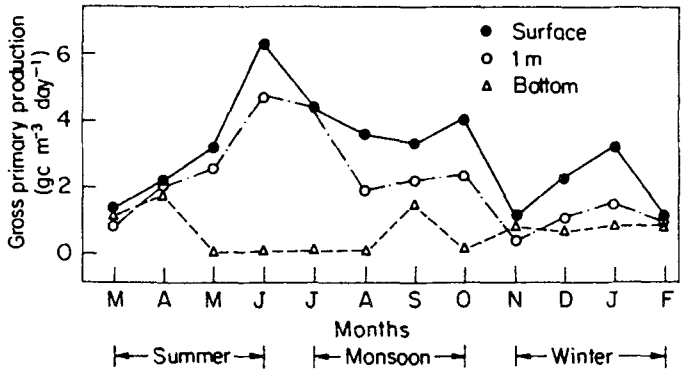


**Figure 3.** Seasonal variation in gross primary production in Lakhotia lake.

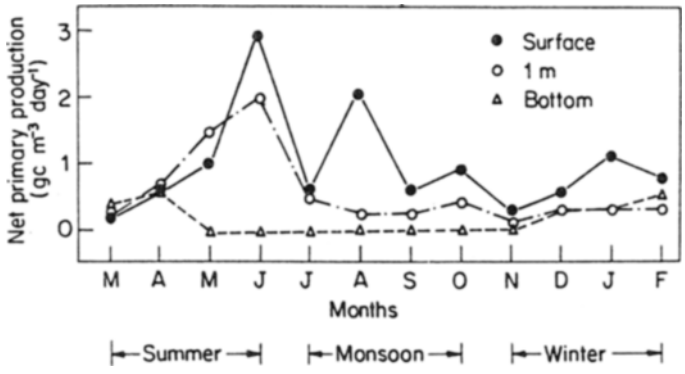


**Figure 4.** Seasonal variation in net primary production in Lakhotia lake.

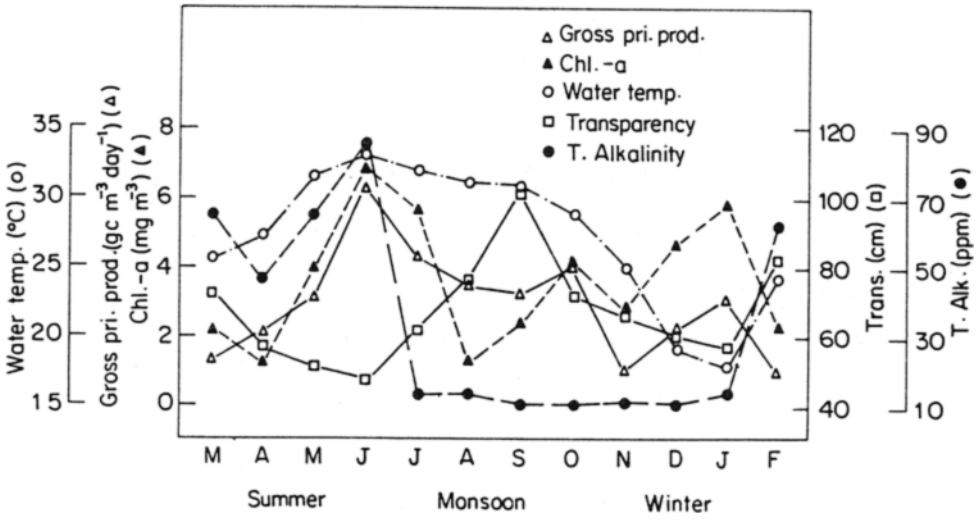


**Figure 5.** Showing inter-relationship between gross primary production, chlorophyll-a, water temperature, transparency and total alkalinity at surface.

## 5. Discussion

The annual gross production in Lakhotia lake was 1956·035 gC $m^{-2}$. On comparing gross primary production with other freshwater bodies it was found higher than the Yercaud lake, Yanamali pond, Teppakulam pond, Aliyar reservoir, Bhavanisagar reservoir and Kodaikanal lake and lower than the Padamsagar, Ranisagar, Ooty lake, Amaravathy reservoir and Othakadai pond (table 1). Comparison with Padamsagar and Ranisagar (Bohra, 1976, unpublished) shows that productivity in these lakes was higher than in the lake under study due to higher chlorophyll-a values, high transparency and greater availability of carbondioxide due to greater benthic decomposition.

**Table 1.** Annual gross production in different freshwater bodies.

| Name | Climate | Annual gross production ($gC\,m^{-2}\,year^{-1}$) | Reference |
|---|---|---|---|
| Padamsagar | Tropical | 4138·91 | Bohra (1976) |
| Ranisagar | -do- | 3451·63 | Bohra (1976) |
| Ooty lake | -do- | 3144·84 | Sreenivasan (1963) |
| Amaravathi reservoir | -do- | 2422·00 | Sreenivasan (1965) |
| Othakadai pond | -do- | 2000·20 | Sumitra (1971) |
| Lakhotia lake | -do- | 1956·03 | Present investigation |
| Yercaud lake | -do- | 1136·24 | Sreenivasan (1963) |
| Yanamali pond | -do- | 857·60 | Sumitra (1971) |
| Teppakulam pond | -do- | 835·90 | Sumitra (1971) |
| Aliyar reservoir | -do- | 730·00 | Sreenivasan (1970) |
| Bhavanisagar reservoir | -do- | 919·80 | Sreenivasan (1974) |
| Kodaikanal lake | -do- | 273·75 | Sreenivasan (1963) |
| Indiana lake | Temperate | 600·00 | Wetzel (1966) |
| Esromso and Furoso | -do- | 200·00 | Jonasson and Methiesen (1959) |
| Clear lake | -do- | 160·60 | Goldman and Wetzel (1963) |
| Lake Leake | -do- | 9.00 | Croome and Tyler (1975) |
| Tome lake | -do- | 9·00 | Croome and Tyler (1975) |

Table 1 shows that gross primary production is higher in the tropical freshwaters than the temperate ones. The reason for higher production in tropical waters seems to be high temperature range and incident solar radiation. This study reveals that increase in water temperature from March onwards accelerated production and in June the temperature and the gross primary production were at their peaks. The linear relation of the primary production with water temperature in monsoon and winter is apparent (figure 5). The study reveals that the production was high within the temperature range 27–33°C which is higher than the range (25°–29°C) reported by Bohra (1976) in the two lakes of Jodhpur.

A linear relationship between primary productivity and chlorophyll-a was apparent in the present study. Whenever there was an increase in chlorophyll-a values, there was a corresponding increase in the rate of primary production in the three seasons. Kalff (1967) in his studies on arctic ponds and Bohra (1976) on two lakes of Jodhpur, observed that chlorophyll-a and primary production were correlated significantly only in certain seasons.

The maximum gross primary production was recorded during summer (figure 5) when there was an increase in water temperature, chlorophyll-a as well as alkalinity. After attaining a peak in June the alkalinity declined sharply during monsoon and consequent flood and in winter it increased again. In this study the linear relationship of alkalinity with production was only during summer months. Sreenivasan (1964) and Sumitra (1971) reported a direct correlation between alkalinity and production throughout their investigations.

In Lakhotia lake the difference between gross and net primary production were wide, the percentage of respiration in gross production being 15·6–100 (figures 3 and 4). The net-gross production ratio fluctuated from zero (November and December) to 0·715 (June). Hundred per cent respiration at certain times and the resultant zero net-gross ratio indicates that respiration exceeds production. Similar instances have been reported previously in certain South Indian waters by Sumitra (1971) and Ganapati and Sreenivasan (1972).

In conclusion, primary production in Lakhotia lake is moderate. Chlorophyll-a and water temperature act as favourable factors whereas transparency and alkalinity are limiting factors.

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