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OBSERVATIONS ON PHYTOPLANKTON, PRIMARY PRODUCTION AND FISH YIELD OF AN OX-BOW LAKE DAH-REOTI, BALLIA (U.P.) INDIA

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ABSTRACT

Observations have been made over a period of two years on the phytoplankton primary production of an Ox-bow lake in relation to abundance and composition of phytoplankton community and physico-chemical variables of water. The relative photosynthetic activities of different algal groups could not be observed due to dominance of blue green algal form *Microcystis aeruginosa*. throughout the year. Maximum production rates coincided with the super abundance presence of blue green forms. High temperature, nutrient loading, high ionic concentration were observed closely associated with higher rates of production. The fish harvest from the lake in relation to primary production suggests a conversion rate of only 0.09% The causative factors for low fish yeild have been discussed and measures to boost up the fishery, suggested.

Figures : 07 References : 19 Tables : 07

KEY WORDS : Ballia, Fish yield, Phytoplankton, Primary production.

Introduction

All heterotrophic life, directly or indirectly depends for its energy requirement upon autotrophs who have unique capacity to trap radiant energy of the sun and transform it into high potential biochemical energy (organic matter) using inorganic matter. Primary production of organic matter in ecosystem provides energy for all endothermic reactions and also supplies electrons needed for all reducing reactions.

The productivity depends upon physical, chemical and biological conditions of any aquatic ecosystem and contributes much towards the energy budget for an active ecosystem. The phytoplankton is of central importance in most aquatic environment because of its role in supporting food webs. Primary production of fresh water bodies is a potential index of productivity for many tropical and sub-tropical ecosystems of the world[19].

The characteristic feature of eastern Uttar Pradesh is the presence of large number of rivers, lakes, ponds, reservoirs and low lying areas. All these water bodies were once teeming with fish but at present due to enormous increase in human population, input of industrial and organic wastes, they are all facing one or the other problem and the fish yield is adversely affected. Therefore, an attempt has been made to observe the seasonal fluctuations in the rate of phytoplankton primary production in relation to certain physico-chemical complexes operating in the water and related fish yield in an ox-bow lake, Dah Reoti (Ballia) in view to suggest measures to improve the lake fishery.

Area of Study

The lake, Dah Reoti extends between the parallels 25**0**40' N and 25**0** 55'N Lat. and 84**0**57' E

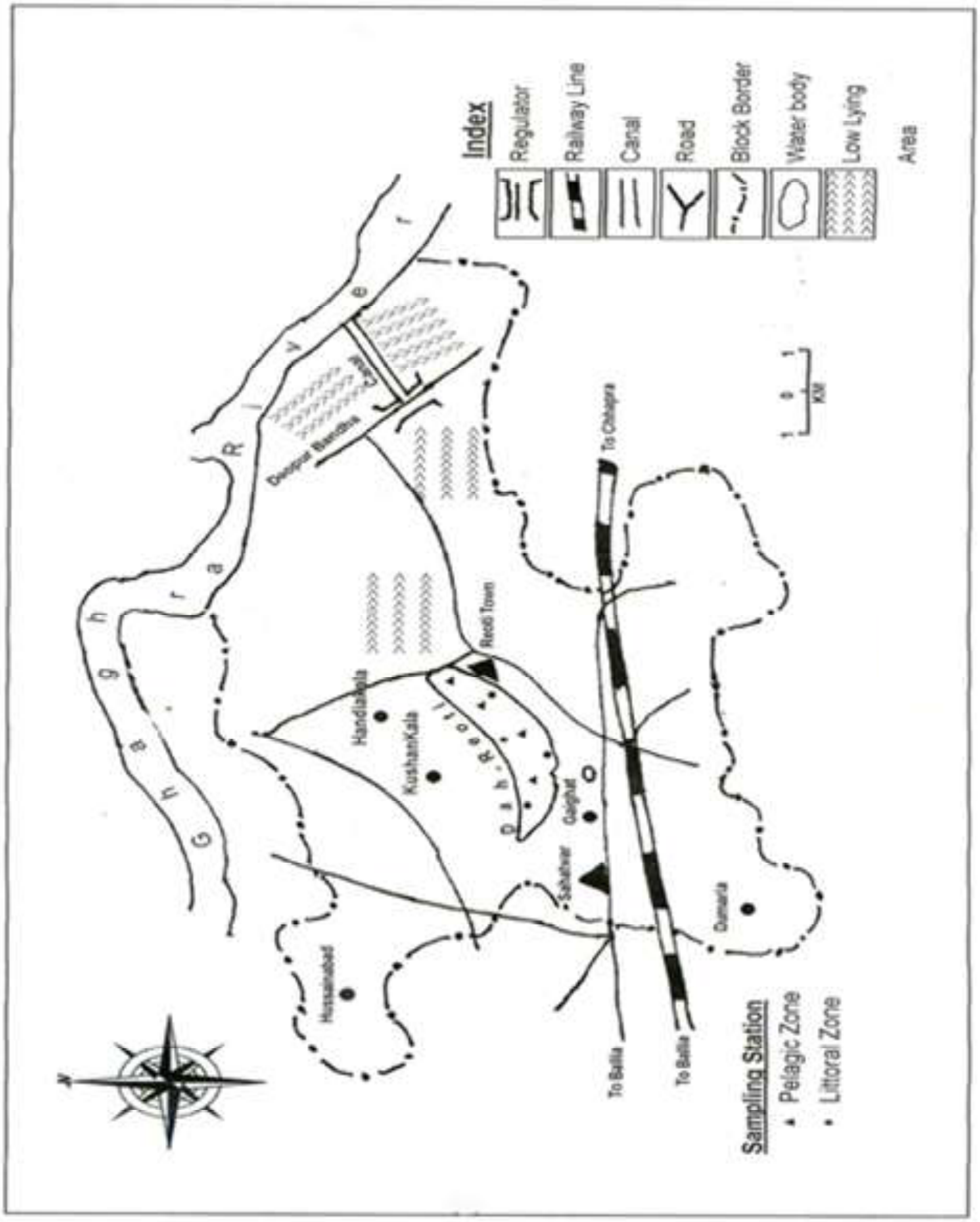

Fig. 1 : DAH-REOTI LAKE and its surroundings Distt. Ballia (U.P.()

85**0**15' E Long. and covers a surface area of 436 hectares of perennial water. It is an ox-bow lake formed by the former channel of river Ghaghra- the two ends having been silted up subsequently to the adoption of a straight course by the river (Fig.1)

The lake receives water from vast agricultural run off during rainy season as also through domestic sewage from small town Reoti

TABLE-1 : Seasonal Variation in Phytoplankton primary production in the lake from October 2004 to September 2006

Season	Primary Production (mg^{c}·m-3·day-1)	
	Average Gross	Average Net
Winter(Nov.-Feb.)	1283.75(27.70)	1060.00(27.27)
Summer (March-June)	1598.75(34.50)	1365.00(35.12)
Monsoon(July-Oct.)	1751.25(37.79)	1461.25(37.60)

Values given in parenthesis reflect percentage of seasonal primary production.

and surrounding villages. The eastern most end of the lake is bordered by a metalled road over a bridge and very occasionally the lake establishes continuity with the river Ghaghra through this bridge when the latter is in heavy spate.

Materials and Methods

The light and dark bottle method was used for estimation of phytoplankton primary production[13]. Two sets of water samples were collected from eight fixed spots both in littoral and pelagic regions in one liter glass stoppered bottles. One bottle from each set was covered with a double layered carbon paper (dark bottle) to prevent light penetration, while the other bottle was kept uncovered (light bottle). Both the bottles were then suspended in water from fixed bamboo poles at 30 cm below the surface. With an incubation period of 24 hrs. the bottles were withdrawn from water and their dissolved oxygen contents were estimated by micro-winkler's method. The initial dissolved oxygen content of water was also determined before incubation.

After estimation of dissolved oxygen from all sampling spots, the following formula was used for calculation of primary production.

$$GPP = \frac{LB - DB}{\text{Time Duration}} \times F$$

$$NPP = \frac{LB - IB}{\text{Time duration}} \times F$$

Where,

GPP= Gross Primary Production

NPP= Net Primary Production

LB= Dissolved Oxygen in Light bottle

DB= Dissolved Oxygen in Dark bottle

IB= Initial Dissolved Oxygen in Water

F = Ratio of Molecular Carbon and Oxygen.

The oxygen production values were converted into their carbon equivalents[10] by multiplying with the factor (F) 0.375.

The physico-chemical variables of water were estimated[1,17] where as the plankton samples were analysed[15].

Observation

It is evident from Table-1 and Fig. 2 that the rate of net primary production differed considerably form season to season. The maximum rate of production was found in October (1940mgC·m-3·day-1) in the first year and in September (1920 mgC·m-3·day-1) in the second year. The minimum values were however, recorded in December during both the years (790 mgC·m-3·day-1 and 770 mgC·m-3·day-1 in the first and second year respectively). The rate of production was found to increase gradually from May onward reaching its maximum in September/October, thenafter started declining till touching the lowest ebb in December.

The variation in gross production displayed an almost similar trend (Table-1, Fig-3). Gross production varied from 830 mgC·m-3·day-1 to 2280 mgC·m-3·day-1 in the first year and from 1010 mgC·m-3·day-1 to 2310 mgC·m-3·day-1 in the second year. The average net and gross production during the period of study were estimated at 1.29 gC·m-3·day-1 and 1.47 gC·m-3·day-1 respectively. Thus, the annual average gross and net productions were estimated at 536.55 gC·m-3·annum-1 and 470.35 gC·m-3·annum-1 respectively.

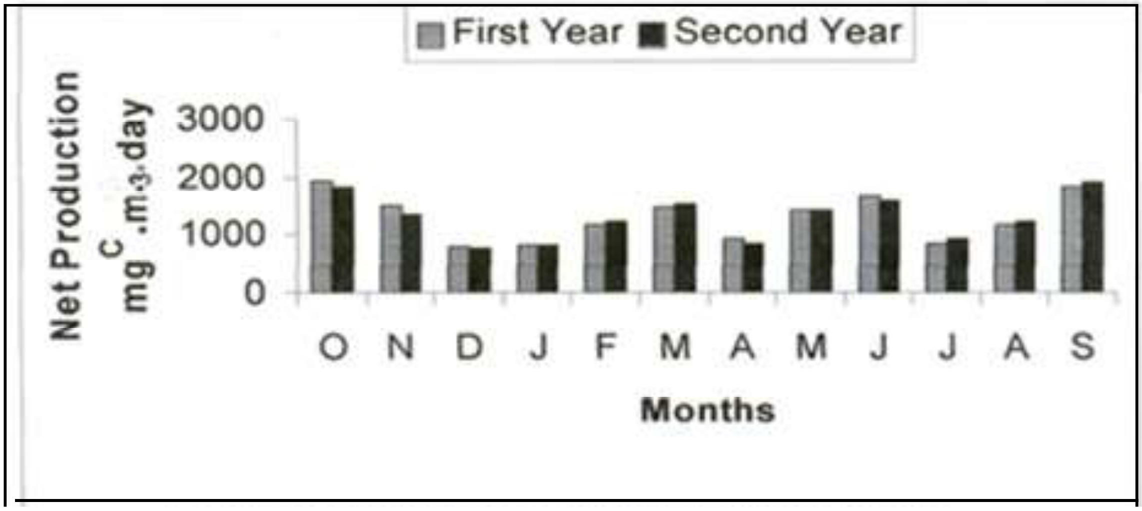

Fig. 2 : Seasonal Fluctuations in Phytoplankton Net Primary Production

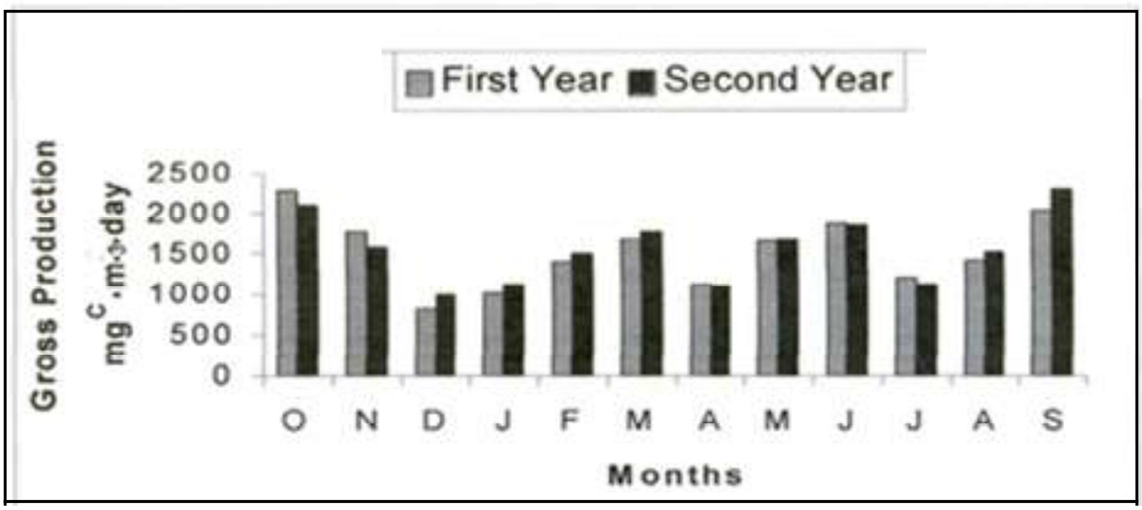

Fig. 3 : Seasonal Fluctuations in Phytoplankton Gross Primary Production

The physico-chemical complexes operating in the lake water during different parts of the year are depicted in Table-2 and discussed in detail[7].

The seasonal abundance and composition of planktonic community are presented in Tables-3,4 & 5 and Figs- 4 & 5. The phytoplankton formed the major bulk of the planktonic community contributing as high as 95.9% of the total plankton.

TABLE -2 : Seasonal Variations in physico-chemical conditions of water from October 2004 to September 2006

Physico-	**Two years monthly average values**											
Chemical factors	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**
Depth (cm)	184.5	176.5	150.5	134.25	128.5	115.25	92.25	103.25	96.273	146.0	223.0	188.25
Transparency (cm)	81.5	88.25	97.95	119.5	108.5	99.75	85.5	72.5	65.0	60.0	52.75	72.50
Water Temperature(ºC)	28.76	24.33	19.45	17.75	19.78	24.4	26.3	30.33	30.45	29.03	29.45	30.00
pH	8.81	8.67	8.60	8.27	8.89	8.80	8.48	8.47	8.40	8.50	8.20	7.95
Dissolved Oxygen(mg•l-1)	12.9	10.14	8.20	9.82	9.95	9.10	7.97	8.03	8.98	11.88	11.75	12.33
Free CO2(mg•l-1)	0	0	0	0	0	3.95	2.85	11.98	10.3	8.28	8.25	7.68
Total Alkalinity(mg•l-1)	108.30	88.30	95.80	92.81	91.09	102.85	95.75	125.0	121.0	111.0	129.45	97.88
BOD(mg•l-1)	6.47	5.98	4.75	3.85	5.60	7.6	10.67	18.85	16.23	25.7	23.4	7.55
COD(mg•l-1)	18.7	12.7	11.05	11.20	9.90	13.7	15.50	14.50	20.00	20.00	19.20	19.00

TABLE - 3 : List of Plankters encountered in the lake Dah-Reoti

Phytoplankton	
Cyanophyceae (Cynobacteria)	*Synedra ulna* (Nitzsch) Her.
Microcystis aeruginosa Kutz.	*S. affinis* Kutz.
M.flos-aquae (Wittrock) Kirchner	*Tabellaria* sp.
Anabaena spiroides Klebahn	*Gomphonema* sp.
A. aphanizominoides Forte	*Navicula* sp.
A. cylindrical Lemm.	
Anabaenopsis sp.	**Chlorophyceae:**
Coelosphaerium kuetzingianum **Nag.**	*Pediastrum simplex* (Meyen)
Nostoc sp.	*P. duplex* (Meyen)
Oscillatoria planktonica Wolosz	*Closterium* sp.
O. splendida Grev.	*Pandorina* sp.
Rivularia sp.	*Volvox* sp.
	Spirogyra sp.
Dinophyceae:	
Ceratium hirundinella (O.F.M.) Bergh	**Eugleninae:**
	Trachelomonas inconstans Carter
Bacillariophyceae:	*T. hipida* Stein
Fragilaria sp.	
Diatoma sp.	
Zooplankton	
Rotifera	**Copepoda**
Brachionus angularis(Goose)	*Mesocylop leuckarti*(Claus)
B. forficula (Wiexzejski)	*Phyllodiaptomus blanet*
B. caudatus (Barrios & Daday)	(De Guerney and Richard)
B. calvciflorusk (Pallas)	
Keratella tropica (Apstein)	**Cladocera**
K. Prockurva (Thorpe)	*Chydorus spaericus* (O.F.Muller)
Monostyla sp.	*Ceriodaphia cormuta* (Sars)
Lecane stichaea (Harring)	*Daphnia lumholtzi* (Sars)
L. hamata (Stokes)	*Sida crystalline* (O.F.Muller)
L. closterocerca (Schmarda)	*Simocephalus* Sp.

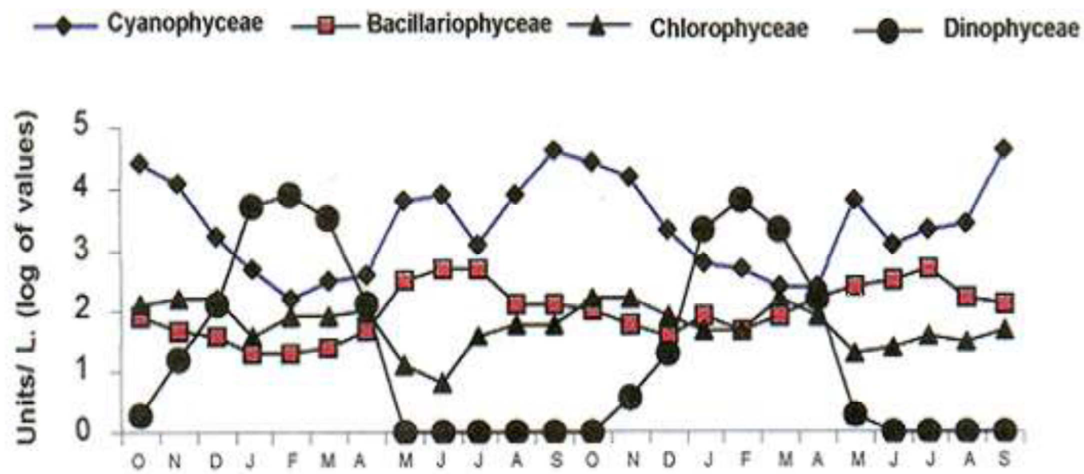

Fig. 4 : Seasonal variations of different groups of Phytoplankton.

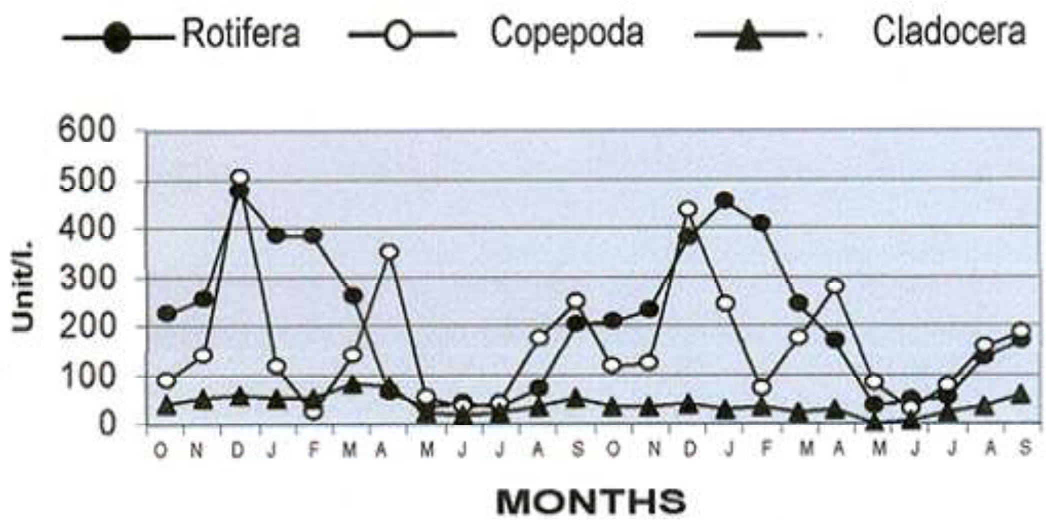

Fig. 5 : Seasonal variations in density of different groups of Zooplankton.

It comprised Cyanophyceae (Cyanobacteria) (85.09%), Dinophyceae (12.03%) Bacillariophyceae (1.68%), Chlorophyceae (0.88%) and Euglenophyceae (0.32%) in order of abundance (Table - 4). The zooplankton formed only a meagre percentage (4.1%) and included chiefly members of Rotifera (50.47 %), Copepoda (40.25%) and Cladocera (9.38 %) in order of abundance (Table-5) .

Owing to huge accumulation of water in the lake, fishing is not done from July to October. Fishing starts with decrease of water level from November to June. The catch increases gradually and touches its maximum level during the month of June when the water reaches its lowest level. There in no proper record maintained either by the government agency or any private organization for total catch from the lake. However, based on the statistical data maintained by the district

TABLE - 4 : Seasonal composition of phytoplankton from 26**KALPANA PALGHADMAL**FUNGICIDE TOLERANCE AGAINST STRAINS OF *BRADYRHIZOBIUM JAPONICUM***25October 2004 to September 2006**

Period	**Composition of different groups (average number×litre-1)**					**Total**	**Percent**
	Cyano-phyceae	**Dino-phyceae**	**Bacillario-phyceae**	**Chloro-phyceae**	**Eugleno-phyceae**	**Density**	**-age**
Winter (Nov.-Feb.)	781	2705	47	110	39	737	13.03
Summer (Mar.-Jun)	3104	694	212	63	37	822	14.54
Monsoon (Jul.-Oct.)	20175	1	215	75	13	4096	72.43
Yearly Average	8020	1134	158	83	30		
Yearly Percentage	85.09	12.03	1.68	0.88	0.32		

TABLE - 5 : Seasonal composition of zooplankton. from October 2004 to September 2006

Period	Composition of different groups(average number×litre-1)				Percentage of total zooplankton
	Cladocera	Rotifera	Copepoda	Total	
Winter (Nov.-Feb.)	44	368	206	206	50.86
Summer (Mar.-Jun)	32	110	141	94	23.21
Monsoon (Jul.-Oct.)	38	135	142	105	25.93
Yearly Average	38	204	163		
Yearly Percentage	9.38	50.37	40.25		

administration for the total catch from Reoti Block for the last five years, information collected from the fishermen as also from the survey of local fish markets and other places where the fishes of the lake are sold, the total average catch is estimated at 60 quintals per annum (Fig.-6). About 200 boats ply in the lake but it was observed that only 120-125 boats are actively engaged at a time.

The catch composition is dominated by forage fishes, murrels and cat fishes (Fig-7). The carps occupy only a mearge percentage of the total catch. The fish fauna of the lake depicted in Table-6, comprises 48 species.

Air breathing fishes like *Heteropneustis fossilis, Clarias batrachus* and *Anabas testudineus* are sent alive to the fish market of Chhapra city (town of Bihar state).

Discussion

A perusal of Table-1 reveals that monsoon season provides the most propitious conditions accounting for more than 37% of total primary production. The presence of blue green forms in super abundance number during this period correlates directly with the primary production. It may be noted that Cyanophyceae is encountered as the most important planktonic group contributing more than 85% of the total phytoplankton. *Microsystis aeruginosa* the most dominant blue green form is observed to form long persisting bloom during post-monsoon period. This species grows luxuriantly from March onward till forming a dense bloom in September/October and persists in considerable number even during the colder months of the year. The diatoms and the green algal forms though known to be more efficient producers than blue green algae and dinoflagellates[5,14] contribute only meagre percentage (1.68 and 0.88%, respectively) to the total phytoplankton population and even the peak periods of these forms are accompanied with greater relative abundance of blue green algal forms. Accordingly, the relationship of different algal groups with carbon assimilation other than blue green algal forms could not be established in the present investigation.

Solar radiation has been directly correlated with primary production[6,8]. The present investigation also establishes such a relationship between the two. The gradual rise in the rate of primary production from April onward indicates a direct

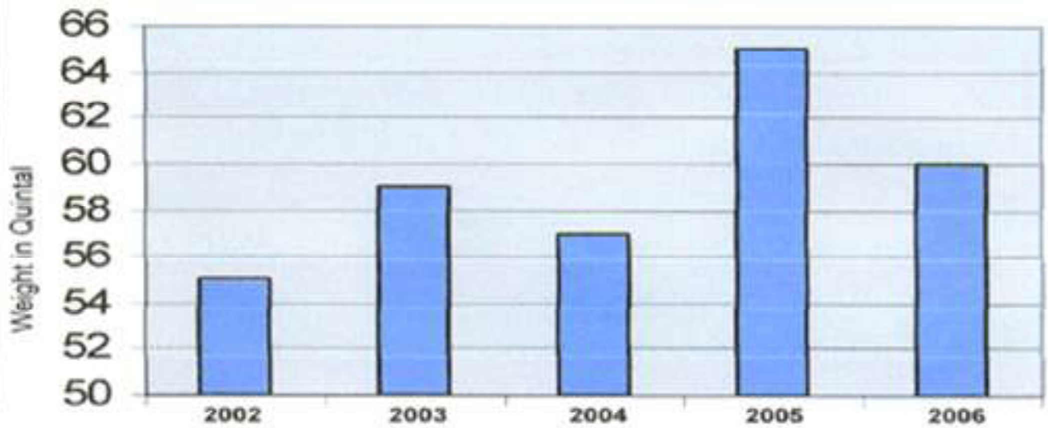

Fig. 6 : Fluctuation in Total fish catch from Dah-Reoti lake

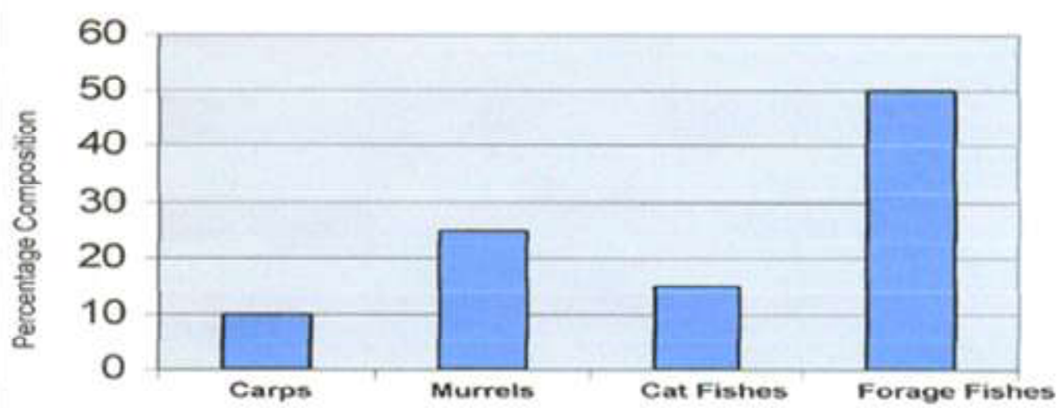

Fig. 7 : Percentage catch composition of Dah-Reoti lake

TABLE- 6 : The fish fauna of the lake comprising 48 species

CLUPEIFORMES	
Gonialosa manmina (Ham.)	
Gudusia chapra(Ham.)	*P.sophore* (Ham.)
G. suhia (Chaudhuri)	*P. ticto* (Ham.)
Notopterus chitala (Ham.)	*Rasbora daniconius* (Ham.)
N. notopterus	
CYPRINIFORMES	
Atlia cotla (Ham.)	BELONIFORMES
Catla catla (Ham.)	*Xenentodon cancila* (Ham.)
Chagunius chagunio (Ham.)	*Hemiramphus gorakhpurensis*
Cirrhinus mrigala (Ham.)	
C. reba (Ham.)	OPHIOCEPHALIFORMES
Clarias batrachus	*Channa gachua* (Ham.)
Clupisoma garua (Ham.)	*C. marultius* (Ham.)
Heteropneustes fossilis (Bl)	*C. orientalis* (Bl and schn.)
Labeo bata (Ham.)	*C. punctatus* (Bl)
L.boga (Man.)	*C. striatus* (Bl)
L.Calbasu (Ham.)	
L. rohita (Ham.)	SYMBRANCHIFORMES
Lepidocephalichthys guntea (Ham.)	*Amphipnuos cuchia* (Ham.)
Wallago attu (Bl. And Schn.)	
Mystus bleekeri (Day)	PERCIFORMES
M. cavasius (Ham.)	*Anabas testudineus* (Bloch),
M. vittatus (Bl.)	*Chanda nama* (Ham.)
M. aor (Ham.)	*C. ranga* (Ham.)
Oxygaster argentea (Day)	*Glossogobius giuris* (Ham.)
O. bacaila (Ham.)	
O.gora (Ham.)	MASTACEMBELIFORMES
Ompok bimaculatus (Bl)	*Mastacembelus armatus* (Lae.)
Puntius chola (Ham.)	*M. pancalus* (Ham.)
P. conchonius (Ham.)	
P. sarana (Ham.)	TETRODONTIFORMES
	Tetraodun fluviatilis

correlation with the intensity and duration of solar radiation. It is , further, observed that there is a gradual decrease in organic production during the winter months accompanied with lower intensity of solar radiation and shorter day length. However, the monsoon months which showed maximum rate of production were very often associated with cloudy days and the month of April though accompanied with greater intensity of sunlight and longer day length exhibited poor production rate. This is obviously an indication of light saturation. Temperature also appears to correlate directly with the observed primary production (r =+0.5774, Table - 7). Workers[4,16] have also observed close relationship between temperature and primary production.

Transparency has a limiting impact on primary production and trophodynamics and it plays an important role in framing community structure[3]. In the present investigation, no doubt the silt load of the lake water during early monsoon caused due to input of heavy run-off from the agricultural field definitely affected the production rate but the late monsoon period accompanied with low visibility caused on account of high density of phytoplankton standing crop failed to affect the production rate[16].

Alkalinity has also failed to correlate directly with observed organic production probably owing to its high concentration in the lake water throughout the year and thus inorganic carbon never becomes a limiting factor.

A comparison of primary production with fish harvest suggests that the potential yield of fish is not realized from the lake. On the basis of average primary production it is estimated that 2.9 x 106 kg·annum-1 carbon is produced in the lake. Carbon value divided by 0.44 give the dry weight of plankton biomass. The total biomass[18] in the lake would therefore be 6.7x106 kg·annum-1. Based on this, at the rate of 100 kg dry weight of plankton equivalent to 1 kg fish, the fish harvest should have been 67646 kg corresponding to 1% conversion but the actual conversion is only 0.09%.

The ultimate factors which determine the potential yield of fish in any aquatic medium is the capacity of the primary producers to manufacture food materials that can be used by heterotrophic organisms. Thus, the actual yield of fish depends on the following two factors:

i) Factors that affect primary production which is itself dependent on the supply of nutrients, temperature, light penetration and the other physico-chemical variables.

ii) Factors that affect the transfer of food material after it is produced. It includes the number of tropic pathways between phytoplankton and fish.

The shallow nature of the lake with an average depth never exceeding 2.5 M even during rainy season, is liable to fast wind action permitting frequent stirring of the lake enabling aeration of different columns and thorough mixing of epilimnion with nutrient rich hypolimnion; high thermal regime in euphotic zone, slightly alkaline water, nutrient rich surface run off from vast agricultrural fields, input of domestic sewage in reasonably low quantity may be considered conducive to high primary production in the lake water.

The lake supports only a small population of low trophic feeders (plankton feeders- viz. *Labeo rohita, Cirrhinus mrigala* and *Catla catla*. The population of carps is neither sufficient enough to utilize all food items nor composed in proper ratio to feed at different niches of the lake water. Moreover, plankton community existing in the lake too, is not desirable and does not constitute preferential food items for plankton feeders. The blue green algal form *Microcystis aeruginosa* and dinoflagellate *Ceratium hirudinella* which form the bulk of phytoplankton are not the natural food items which the fish prefers under favourable conditions. In fry of carps these remain undigested in the gut and ejected intact alongwith the faecal matter[9]. Thus, the huge energy fixed by the autotrophs does not get converted into fish flesh and settles to the bottom after death in the form of detritus and organic mud. Spawn and fry of carps with a short and straight intestine are reported to digest rotifers and cladocerans fairly rapidly and thrive well on zooplankton but the zooplankton in the lake water exhibits only a depressed population (4.1%) of plankton community.

Carnivorous and predacious fishes which constitute a significant population of the fish fauna in the lake are obtained at the end of long food chain and that too, at the cost of carp fry, fingerlings and even the yearlings flourishing at lower trophic levels. Indiscriminate fishing is further detrimental to carp fishery. The carps are caught and sold at the very early stage without permitting them to attain marketable size. The intensive and indiscriminate

TABLE - 7 : Co-rrelation coefficients

Factors of CorrelationCorrelation	**Coefficient ('r' value)**
Primdary production vs Temperature	+0.5774
Primary production vs Alkalinity	+0.1842
Primary production vs. Cyanophyceae	+0.597
Primary production vs Bacillariophyceae	+0.6847
Primary production vs Chlorophyceae	+0.8166

fishing round the year without any control magnify the loss to a great extent and deprives the lake of a good percentage of carps at various stages of development.

The following measures are, therefore suggested to boost up the fish production from the lake:-

1- (i) Central or State fisheries department should take over the control of fisheries management of the lake. However, if it is not possible, an effective cooperative society of fishermen be constituted and be kept under the supervision of some appropriate district authority. The fishermen should be trained with modern techniques involved in fish culture and be entrusted the job of procurement and introduction of seeds in adequate number and in proper ratio and composition, rearing of fingerlings and harvesting as also the marketing of catch at appropriate time. Culture of Indian major carps viz. *Catla catla*. (surface feeder), *Labeo rohita* (column feeder) and *Cirrhinus mrigala* (bottom feeder) has a great promise in this lake. They are known for their taste and nutritive value, rapid growth and compatibility with other fishes and close to the primary producer in food chain. More so, they are in high demand in the market and fetch high prices as compared to other fishes.

(ii) To ensure high productivity, construction of hatcheries at the lake site itself is suggested to raise fingerlings of desirable fish to stock the lake.

(iii) Huge shallow inundated low lying areas towards eastern side between the lake and the river Ghaghra may act as breeding grounds for the carps, if *Eichhornia crassipes* is completely eradicated from this region.

2 (i) Another constraint to the lake fishery is the presence of thick floating submerged and emerged vegetation. *Eichhornia crassipes* and *Pistia stratiotes* should be controlled mechanically whereas, the other macrophytes be controlled biologically through introduction of some known effective exotic carps.

To control submerged weeds, some selective varieties of herbivorus exotic fishes like grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*) and tawes (*Puntius javanicus*) should be introduced into the lake. They consume a wide variety of weeds as their food and to a large extent do not biologically interfere with other fishes and are also economical to maintain.

(ii) The blue green algal form *Microcystis aeruginosa* which forms bloom during post monsoon period and persists round the year in the lake in significant number is the most noxious consuming most of the dissolved nutrients and serving no use to the fish as food. An effective control of this algal form would permit desired plankters to grow in the lake.

3. The low yield of fish besides being consequence of other factors, is also partly attributable to the unrestricted growth and abundance of carnivorus/predacious and

trash fishes in the lake. While the former is obtained at the end of a long food chain and that too, at the cost of fry and fingerlings of carps beside others, the latter according to worker[12], at some stages of their life history compete for food with major carps. Contribution of trashes in lowering fish yield is well recognised and the importance of control of these fishes has been emphasized[2,11]. In addition these weed fishes provide forage base for the development of predatory cat fish population which in turn affect the recruitment potential of economic carps.

In such a shallow lake, large fraction of trash fishes can be effectively removed by using close meshed dragnets.

Conclusion

The results obtained during this investigation, suggest that if scientifically managed, exploited and developed, the lake Dah- Reoti would not only cater to the needs of fish- eating population of this region but would also help solve the poor economy to a great extent. In addition, it would be a good centre for picnic, recreational fishery, angling and rowing as also a decoration of this remote area.

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