

ECOLOGY AND FISHERIES OF BHATGAR RESERVOIR



**CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
BARRACKPORE 743 101 WEST BENGAL**

INTRODUCTION

Ecology and Fisheries of Bhatgar Reservoir

*Reservoir Fisheries Division
of CIFRI*



Bull. No. 73

Feb. 1997

(Issued on the occasion of Golden Jubilee Celebrations)

Central Inland Capture Fisheries Research Institute
(Indian Council of Agricultural Research)
Barrackpore 743101 west Bengal

Ecology and Fisheries of Bhatgar Reservoir

(Golden Jubilee Bulletin of CIFRI)

ISSN 0970-616 X

©
1997

*Material contained in this Bulletin may not be reproduced, in any form,
without the permission of the publisher*

Edited and composed at : **The Project Monitoring &
Documentation Section
CIFRI Barrackpore**

Published by : **The Director, CIFRI Barrackpore**

Printed at : **Calcutta Laser Graphics (Pvt.) Ltd
71, Hari Ghosh Street
Calcutta 700 006**

FOREWORD

Although reservoirs form one of the most important inland fishery resources of Maharashtra, very few reservoirs in the State have been subjected to scientific investigations. In order to fill this gap, Pune Centre of the Central Inland Capture Fisheries Research Institute has initiated studies on the limnology and fish productivity of Bhatgar reservoir in the year 1987. The Centre could successfully carry out the investigations with the active cooperation of the State Government and the local people. I am glad that the data generated by the Project has brought to focus some important facts about Bhatgar reservoir with a definite bearing on the management strategies to be adopted. The studies have led to some useful recommendations for the management of Bhatgar reservoir which are equally applicable to other reservoirs in the State.

I hope the authorities will formulate the management practices for the reservoir based on the findings of this project.

Dr. M. Sinha
Director
CIFRI

**The following Scientific and Technical staff of Central Inland Capture Fisheries
Research Institute participated in the Project**

| <i>Name</i> | <i>Designation</i> | <i>Duration</i> |
|-----------------------|---------------------------------------------------|----------------------|
| Shri B. V. Govind | Principal Scientist & Head, Reservoir Division | June 1987 - Dec 1988 |
| Dr. Y. Rama Rao | -do- | Jan 1989 - Jul 1989 |
| Shri P. L. N. Rao | Senior Scientist | Jun 1987 - - |
| Dr. M. D. Pisolkar | Senior Scientist | 01.04.85 - - |
| Dr. B. K. Singh | Senior Scientist | Jun 1987 - - |
| Dr. B. L. Pandey | Scientist | Aug 1989 - Oct 1993 |
| Shri V. Kolekar | Scientist | Jun 1987 - Dec 1988 |
| Shri R.N. Seth | Senior Scientist | 19.11.90 - 12.04.91 |
| Shri S. K. Srivastava | T-II-3 | Dec 1990 - Oct 1992 |
| Shri Debashis Saha | T-1 | Dec 1988 - Sep 1991 |

CONTENTS

| | | |
|------------------------------------------------------------------------|------|----|
| INTRODUCTION | .... | 1 |
| SAMPLING PROCEDURE | .... | 2 |
| METEOROLOGICAL, MORPHOMETRIC AND HYDROGRAPHICAL OBSERVATION | .... | 3 |
| Rainfall | .... | 3 |
| Description of the dam | .... | 3 |
| Reservoir level | .... | 6 |
| Inflow and outflow | .... | 6 |
| Capacity | .... | 8 |
| LIMNOLOGY AND PRODUCTIVITY OF THE RESERVOIR | .... | 8 |
| Physico-chemical characteristics of soil and water | .... | 8 |
| Primary productivity | .... | 13 |
| BIOTIC COMMUNITIES | .... | 15 |
| Bottom biota | .... | 15 |
| Plankton | .... | 15 |
| Periphyton | .... | 18 |
| Fish fauna | .... | 18 |
| COMMERCIAL FISHING | .... | 19 |
| Fishing units | .... | 19 |
| Yearly variations in fish yield | .... | 19 |
| Performance of individual species | .... | 20 |
| Catch per unit effort | .... | 21 |
| Fishery biology | .... | 21 |
| BIOLOGY OF FISHES | .... | 22 |
| Food and feeding habits | .... | 22 |
| Breeding biology | .... | 22 |
| STOCKING OF THE RESERVOIRS | .... | 22 |
| CONCLUSIONS AND RECOMMENDATIONS | .... | 23 |

Dr. M. Subh
Director
CFRI

INTRODUCTION

A large number of impoundments have been created in the country since independence to harness river water for the purpose of irrigation, power generation, flood control and navigation. Consequently, there has been a manifold increase in the construction of dams on different river valley basins, resulting in the number of man-made reservoirs. By 1976 the country had an estimated 3 million hectares of water area under reservoirs. Per hectare yield of Indian reservoirs is very low averaging about 20 kg/ha/yr. In the final report of IDA-assisted Pilot Project on reservoir fisheries management in Rajasthan the scope and potential for generating additional income of the order of Rs. 1,000 million per year has been outlined, in addition to augmenting of employment opportunities several fold by the implementation of managerial measures in these unutilised fisheries resources. Construction of a dam and the resultant creation of a new artificial impoundment result in altered hydrology both up- and downstream. As the reservoirs exhibit wide degree of variations on their shape, runoff, soil type, climatic factors and human interference, the problems related to fishery management and their solutions are location specific.

The All India Coordinated Projects on Ecology and Fisheries of Freshwater Reservoirs initiated in the year 1971 has brought to focus some basic facts about productive capacities of some large reservoirs in India. The present study is a continuation of the investigations carried out under the Coordinated Project, pertaining to Bhatghar reservoir of Pune district of Maharashtra. Rivers of Maharashtra originating from the Western Ghats region have been harnessed since long for irrigation, power generation and flood control, resulting in innumerable reservoirs. Bhatghar reservoir created by damming Yelwandi river in Bor taluka, Pune district is one such reservoir. Came into being well before independence, it took over 16 years to erect the dam (1912-1928). The foundation stone of the dam was laid by the then Governor of Bombay on 25.10.98 and the dam was named after him as Lloyd's dam. Later it has been rechristened as *Yesaji Kank Jalasai* popularly referred to as Bhatghar reservoir after the village that was submerged in the impoundment.

Biological investigations were initiated in Bhatghar reservoir from 1987 to assess its morphometric features, physico-chemical characteristics of water, fishery potential, species composition, fish catch structure, etc. The reservoir was said to be very low yielding 2-3 kg/ha/yr.

SAMPLING PROCEDURE

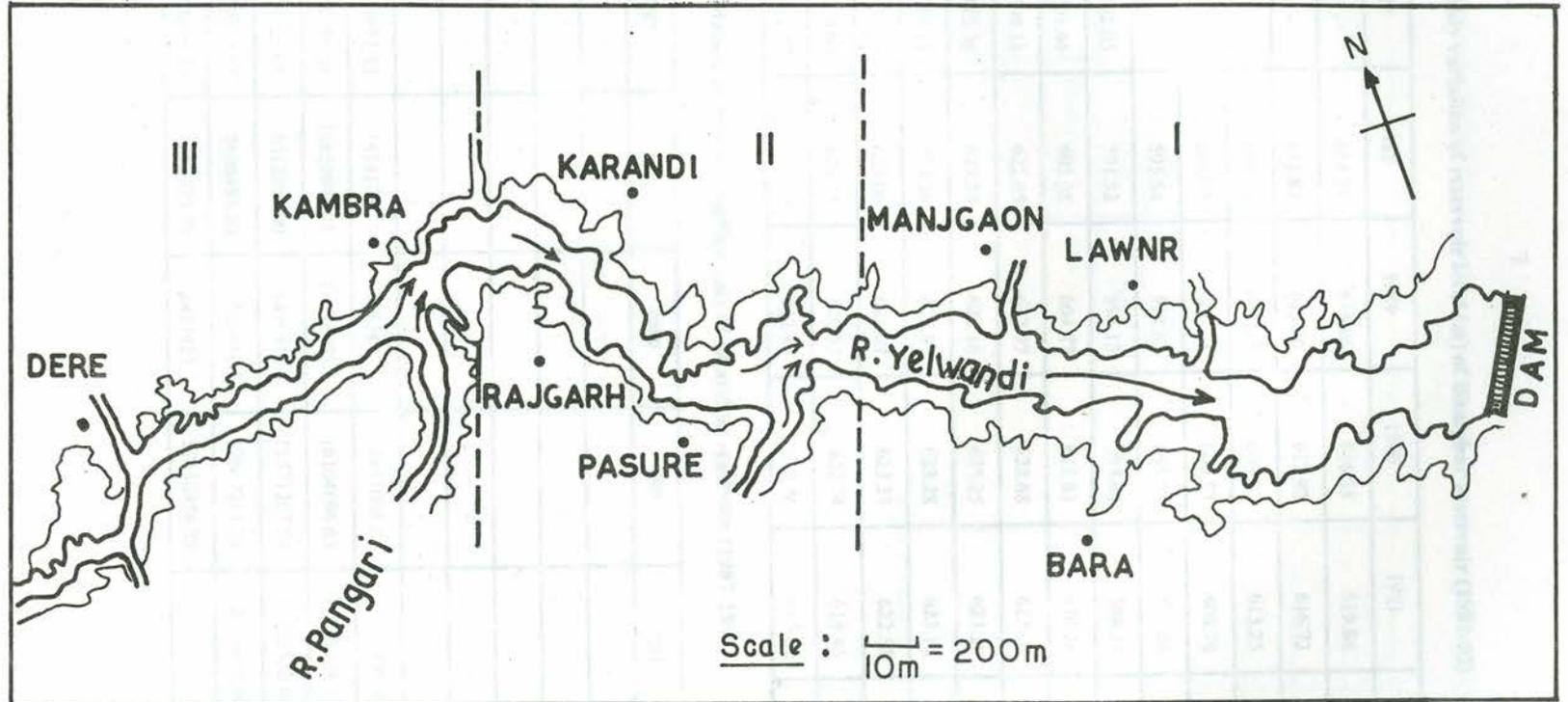
Sampling was carried out in accordance with the methodology on reservoir fisheries investigations in Indian.

Bhatghar reservoir was divided into three sectors viz., lentic which is close to the dam site and deeper between the village Sangvi to Pasure. Intermediate sector starts from Pasure to Kamre with waters being standstill and lotic sector starts from Kamre to Dare. On either banks it is strewn with hills the uppermost reaches being with mild forests. Sectoral demarkation of the reservoir is depicted in Fig. 1. Soil samples were collected from three sectors during pre-monsoon (April-June) and post-monsoon (November to January) months with the help of Ekman dredge. Parameters like texture of the soil viz., sand, silt and clay and chemical parameters like organic carbon, available phosphorus, available nitrogen was carried out.

Fortnightly samples of water was collected from different sectors and the analysis was carried out. Physical parameters like air temperature, water temperature, pH, transparency and chemical features like dissolved oxygen, free carbon dioxide, total alkalinity, chlorides, hardness, phosphates, silicates, specific conductivity, total dissolved solids were estimated following the standard method APHA (1985). The same were also analysed with the help of Century make water analyser kit. The thermal stratification was studied in all the sectors at every meter upto the compensation depth. The estimation of primary productivity was carried out in all the three sectors through *Light & Dark Bottle technique* and ^{14}C techniques was also carried out. Monthly observations on the quantity and quality of benthic organisms were made with the help of Ekman dredge in the three sectors, using sieve no. 40.

Besides collecting the specimens from commercial catch for faunistic studies spawn and fry collections were also made during monsoon months. Besides scoop nets were also operated in shallow areas of the reservoir. During June, 1987 to March 1992, sampling of commercially operated gill nets was undertaken every month to collect the data on net-wise catch and length and girth of fish in relation to the mesh-bar. Drag nets locally referred to as ODAP JAL were operated during the summer season (March-June) restricted only to the lentic zone. Gill nets were operated for three days in each the fortnight in the entire stretch of the reservoir. Experimental fishing was carried out by gill nets with mesh bars ranging from 20-150 mm. Studies on the length-weight relationship, age and growth and also fecundity of commercially important species was carried out.

Fig. 1 Map of Bhatghar reservoir



Plankton samples were collected by filtering 50 liters of water through a net made of nylobolt no. 25 and were analysed both quantitatively and qualitatively using sedgewick rafter cell. Depth-wise collections of plankton were also made. Periphyton samples were collected from the lentic sector only covering both the banks. The periphyton forms were gently detached from the substratum through mild scrapping. The samples were then transferred to a beaker containing a little water and its volume made up to 100 ml. Quantitatively and qualitatively analyses were made by the use of sedgewick rafter cell.

Landings from commercial fishing was recorded from the lentic sector only because of paucity of fishing in the other zones. A proforma in regional language was supplied for the fish landing to all active fish farmers. The data on fish catch, species composition (by weight and numbers) were collected and yield/ha was estimated.

METEOROLOGICAL, MORPHOMETRIC AND HYDROGRAPHICAL OBSERVATIONS

Rainfall (mm)

Bhatghar reservoir is mainly rainfed with a catchment area of 336.0 sq. km. Data of rainfall from 1987 to 1992 during different quarters are presented in Table I. The annual precipitation of the years was found to be 6412.08 mm and ranged between 547.4 (1987) to 2153.20 (1991). The maximum rainfall was recorded in the 3rd quarter of the years while the minimum was in the 1st quarter. About 67.99% of the annual precipitation was recorded in the 3rd quarter *i.e.*, July-September of the years. This indicates that precipitation is the main source of the reservoir. Previous records show that maximum rainfall was recorded during 1976 (1415.7 mm). In the year 1991 highest rainfall of 2153.20 mm surpasses the previous record. Monthly variation of rainfall during different years is presented in Table II.

Description of the dam

Bhatghar dam is located within the geographical coordinates of latitude 18°10' N and longitude 72° 52' E across the river Yelwandi near Bhor village, 50 kilometers away from Pune on Pune-Mangalore highway in the Pune district of Maharashtra. The river originates at around six kilometers upstream of village Dore and flows towards east and joins river Nira at Sangvi, which ultimately joins Krishna through Bhima. The dam is constructed by solid masonry in lime-mortar in the ratio of 1:2. The length, height and width of the dam are 1625 m, 43 m and 38 m respectively. The entire length of the dam is flanked on either bank with steep hills and has moderate forest at its origin.

Table I. Reservoir level, Inflow, Outflow and Rainfall of Bhatghar reservoir during different quarters of the years 1987-1992.

First quarter- from January to March

| YEARS | QUARTER | Reservoir level (m) | Inflow (m ³) | Outflow (m ³) | Rainfall (mm) |
|---------|---------|---------------------|--------------------------|---------------------------|---------------|
| 1987 | I | date not available | | | |
| | II | 592.05 | 985997.33 | Nil | 64.5 |
| | III | 608.64 | 14174406.21 | Nil | 310.9 |
| | IV | 616.11 | 1204406.26 | Nil | 172.0 |
| Average | 605.60 | 5454936.60 | Nil | 547.4 | |
| 1988 | I | 611.62 | Nil | 8073371.77 | Nil |
| | II | 597.04 | 1414175.75 | 5411788.36 | 85.6 |
| | III | 616.97 | 25950132.27 | 9879993.39 | 984.8 |
| | IV | 622.49 | 258375.50 | 4497916.87 | 15.2 |
| Average | 612.03 | 9207561.17 | 6965767.60 | 1085.6 | |
| 1989 | I | 613.65 | Nil | 8731608.87 | 17.8 |
| | II | 599.82 | 2883810.32 | 3326624.38 | 175.4 |
| | III | 614.97 | 18902332.84 | 152548.50 | 642.6 |
| | IV | 622.12 | 1177704.77 | 266133.87 | 16.0 |
| Average | 612.64 | 7654615.98 | 3119228.90 | 851.8 | |
| 1990 | I | 613.10 | Nil | 2543298.97 | Nil |
| | II | 598.33 | 2861098.14 | 3504601.71 | 152.0 |
| | III | 619.25 | 45343175.43 | 160600.55 | 1197.7 |
| | IV | 623.16 | 17636618.38 | 2081859.95 | 425.5 |
| Average | 613.16 | 21946963.99 | 2072590.29 | 1775.2 | |
| 1991 | I | 615.50 | Nil | 6671677.93 | Nil |
| | II | 603.08 | 7735209.94 | 8025842.62 | 924.4 |
| | III | 618.83 | 32296056.87 | 10878741.86 | 1223.8 |
| | IV | 621.64 | Nil | 5811625.49 | 5.0 |
| Average | 615.01 | 20015633.41 | 7846971.97 | 2153.2 | |
| 1992 | I | 611.02 | Nil | 6592968.48 | Nil |

Table II. Monthly variation in Rainfall (mm) Bhatghar Reservoir (1987-92)

| Months | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|-----------|-------|--------|-------|--------|--------|------|
| January | - | - | - | - | - | - |
| February | - | - | - | - | - | - |
| March | - | - | 17.88 | - | - | - |
| April | - | - | - | - | 75.4 | - |
| May | - | 6.0 | 25.0 | 16.0 | 57.0 | - |
| June | 64.5 | 79.0 | 150.4 | 136.0 | 792.0 | - |
| July | 95.9 | 548.0 | 291.6 | 783.6 | 629.0 | - |
| August | 162.9 | 135.2 | 139.0 | 347.3 | 494.8 | - |
| September | 52.1 | 301.6 | 212.0 | 67.0 | 5.0 | - |
| October | 97.2 | 15.2 | 13.0 | 416.0 | - | - |
| November | 48.8 | - | 3.0 | 9.5 | - | - |
| December | 26.0 | - | - | - | - | - |
| Total | 547.4 | 1085.0 | 851.8 | 1775.4 | 2053.2 | |

The salient morphometric features are as follows :

1. Year of construction

- a) Commencement : 1912
 b) Completion : 1928

2. Purpose : Irrigation and power generation

3. Dam details

- i) Length of the dam : 1625 m
 ii) Maximum height from river bed : 43 m
 iii) Full sill level : 623.285 m
 iv) Top of dam level : 626.637 m

| | | | |
|--------|----------------------------------------|---|-----------------------|
| v) | Gross storage | : | 672.6 million cubic m |
| vi) | Maximum height above lowest foundation | : | 58 m |
| vii) | Discharge capacity | : | 1600 cusecs |
| viii) | Length of spill way | : | 325.5 m |
| ix) | Number of Wasteweir - Automatic | : | 45 Size 2.43 x 3.0 m |
| x) | -do- Non-Automatic | : | 36 -do- |
| xi) | Number of irrigation sluices (south) | : | 6 (2.43 x 1.21 m) |
| xii) | Head of water above sill level | : | 15 m |
| xiii) | Number of irrigation sluices (north) | : | 6 (2.43 x 1.21 m) |
| xiv) | Head of water above sill level | : | 26 m |
| xv) | Number of Bed sluices | : | 8 (1.21 m) |
| xvi) | Head of water above sill level | : | 43 m |
| xvii) | Catchment area | : | 336.0 sq.km. |
| Xviii) | Maximum length of reservoir | : | 45 km at FRL |
| xix) | Mean depth | : | 24.02 m |
| xx) | Factory effluents | : | Nil |

Reservoir level

The average reservoir level was found to be 611.63 m and ranged from 605.60 (1987) to 615.01 (1991). The maximum level was attained in the fourth quarter of the year and the minimum is second quarter. The monthly variation of reservoir level is presented in Table III. The first quarter commences from January to March.

Inflow and outflow

The average inflow was found to be 128,63,942.23 m³ and ranged from 54,54,936.99 (1987) to 219,46,963.99 (1990). Maximum inflow was recorded in the third quarter of the years while it was nil in the first quarter. Monthly variation of inflow during different years are presented in Table IV. Data of outflow from the reservoir during different quarters of the years is presented in Table I. The average outflow was found to be 5319505.45 m³ and ranged from 2072590.29 (1990) to 7846971.97 (1991). The maximum outflow was recorded in the 1st and 2nd quarters of the years, as the reservoir water is released for irrigation purpose and also for power generation. Monthly variation of outflow during different years are presented in Table V.

Table III. Monthly variation of reservoir level (m) of Bhatghar reservoir (1987-92)

| Months | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|-----------|--------|--------|--------|--------|--------|--------|
| January | - | 614.21 | 616.96 | 616.55 | 619.84 | 615.26 |
| February | - | 611.83 | 613.50 | 612.92 | 616.72 | 610.61 |
| March | - | 608.91 | 610.57 | 609.83 | 613.25 | 608.18 |
| April | - | 604.07 | 606.71 | 605.53 | 608.76 | - |
| May | - | 595.54 | 598.62 | 595.99 | 601.65 | - |
| June | 592.05 | 591.52 | 594.13 | 593.48 | 598.83 | - |
| July | 601.46 | 605.02 | 604.77 | 611.81 | 610.26 | - |
| August | 609.11 | 622.65 | 617.97 | 622.68 | 623.02 | - |
| September | 615.36 | 623.29 | 622.16 | 623.25 | 623.20 | - |
| October | 616.11 | 623.26 | 622.97 | 623.28 | 623.16 | - |
| November | 616.19 | 623.06 | 622.84 | 623.23 | 622.55 | - |
| December | 616.03 | 621.15 | 620.55 | 622.94 | 619.46 | - |
| Average | 612.37 | 612.03 | 612.64 | 613.46 | 615.06 | 611.02 |

Table IV. Monthly variation of reservoir inflow (m³) of Bhatghar reservoir (1987-1992)

| Months | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|-----------|------------|-------------|------------|-------------|-------------|------|
| January | - | - | - | - | - | - |
| February | - | - | - | - | - | - |
| March | - | - | - | - | - | - |
| April | - | - | - | - | - | - |
| May | - | - | - | - | - | - |
| June | 985997.33 | 1414175.75 | 2883810.3 | 2861098.15 | 7735209.90 | - |
| July | 6606355.94 | 15829996.75 | 11136725.8 | 16104696.63 | 19718674.10 | - |
| August | 5478725.65 | 6512864.00 | 6496916.9 | 11571267.51 | 10505532.80 | - |
| September | 2089324.62 | 3608495.20 | 1269410.1 | 17667211.29 | 2070870.90 | - |
| October | 1204406.26 | 258375.50 | 2401421.3 | 17550958.22 | - | - |

Table V. Monthly variation of reservoir outflow (m³) of Bhatghar reservoir (1987-1992)

| Months | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|-----------|------|------------|------------|------------|------------|------------|
| January | - | 2957478.05 | 3568357.70 | 7880.70 | 3724014.10 | 3185296.63 |
| February | - | 2268501.19 | 2868220.20 | 24474.30 | 2947663.80 | 2914794.82 |
| March | - | 2847392.50 | 2292681.80 | 2510821.50 | 3351808.50 | 2304380.56 |
| April | - | 3728908.94 | 3277773.60 | 3439230.80 | 4160562.70 | - |
| May | - | 1682854.94 | 24474.30 | 2028921.90 | 3279070.80 | - |
| June | - | - | 24474.30 | 451790.60 | 586062.30 | - |
| July | - | - | 24474.30 | 24474.30 | 24474.30 | - |
| August | - | 5831449.70 | 24474.30 | 136126.20 | 9351005.20 | - |
| September | - | 4048543.70 | 103599.80 | - | 1493423.60 | - |
| October | - | 201081.00 | 145255.10 | 244743.30 | 244743.30 | - |
| November | - | 879607.43 | 75870.40 | 186763.60 | 2034624.50 | - |
| December | - | 3417154.93 | 45008.30 | 1650353.00 | 4632917.30 | - |

Capacity (m³)

The monthly average water capacity of the reservoir indicated direct relationship with the average water level. Monthly variations during different years are presented in Table VI. The yearly average water capacity ranged from 316133852.2 (1992) to 446743676.4 (1991).

LIMNOLOGY AND PRODUCTIVITY OF THE RESERVOIR

Physico-chemical characteristics of soil and water

Soil: Data on soil samples during pre-monsoon and post-monsoon are presented in Table VII. The texture of bottom soil is sandy, reddish in colour and poor in quality. The soil was alkaline in nature and there is very little variation in pH range. Organic carbon, available phosphorus and available nitrogen were relatively high during post-monsoon months. The overall percentage of sand is always high. The percentage of clay

Table VI. Monthly variation of reservoir capacity (m³) of Bhatghar reservoir

| Months | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 |
|-----------|--------------|-------------|-------------|-------------|--------------|-------------|
| January | - | 399395721.4 | 478104249.2 | 466195902.1 | 564401396.2 | 428818292.5 |
| February | - | 331407934.1 | 492637280.5 | 363667565.4 | 461981512.8 | 302653639.6 |
| March | - | 258635457.2 | 299204370.2 | 281626999.7 | 372749612.6 | 216929624.6 |
| April | - | 149339809.1 | 206643830.2 | 197427561.3 | 254766249.6 | - |
| May | - | 40237444.0 | 73929501.4 | 49080376.8 | 108646747.7 | - |
| June | 20217251.3 | 18194393.5 | 31979011.7 | 29627018.3 | 78899099.8 | - |
| July | 123730823.9 | 20510424.6 | 173352617.9 | 341596035.6 | 312817388.6 | - |
| August | 237796274.5 | 652789738.9 | 509544392.3 | 654315448.1 | 664361399.2 | - |
| September | 181535572.6 | 671433803.2 | 636664454.0 | 671632587.1 | 6721184198.4 | - |
| October | 453063419.8 | 671881775.0 | 662611137.8 | 672580633.6 | 668520004.5 | - |
| November | 455356797.4 | 643083023.0 | 658444887.0 | 672476144.6 | 649104024.2 | - |
| December | 450873681.7 | 599962766.3 | 586017025.5 | 661928136.6 | 552492199.6 | - |
| Average | 3358726000.6 | 371419006.2 | 400761157.5 | 421846130.0 | 446743676.4 | 316133852.2 |

Table VII. Physico-chemical characteristics of soil of Bhatghar reservoir (1987-92)

| | PRE-MONSOON | | | POST-MONSOON | | |
|------------------------|---------------|---------------------|--------------|---------------|---------------------|--------------|
| | <i>Lentic</i> | <i>Intermediate</i> | <i>Lotic</i> | <i>Lentic</i> | <i>Intermediate</i> | <i>Lotic</i> |
| Sand (%) | 68.2 | 62.4 | 58.7 | 50.2 | 48.4 | 55.5 |
| Silt (%) | 11.9 | 10.3 | 13.1 | 15.6 | 13.8 | 12.2 |
| Clay (%) | 19.9 | 27.3 | 28.2 | 34.2 | 37.8 | 32.3 |
| pH | 7.0 | 7.0 | 7.1 | 7.3 | 7.1 | 7.2 |
| Organic carbon (%) | 0.46 | 0.38 | 0.41 | 0.38 | 0.36 | 0.31 |
| Available P (mg/100 g) | 1.68 | 1.64 | 1.50 | 2.30 | 1.80 | 2.00 |
| Available N (mg/100 g) | 15.50 | 15.60 | 20.10 | 20.10 | 18.40 | 22.20 |

increased during the post-monsoon months due to the heavy influx of rain water from the catchment area.

Water: Sectoral variations in respect of physico-chemical parameters of the reservoir are presented in Table VIII.

Table VIII. Sectoral physico-chemical characteristics of water of Bhatghar reservoir (1987-92)

| Parameters | Lentic | | Intermediate | | Lotic | |
|-------------------------------|-------------|---------|--------------|---------|------------|---------|
| | Range | Average | Range | Average | Range | Average |
| Air temp.(°C) | 15.0-36.4 | 23.95 | 22.0-36.5 | 28.14 | 24.0-37.5 | 30.37 |
| Water temp. (oC) | 17.0-30.8 | 24.78 | 22.5-31.0 | 26.42 | 21.8-31.0 | 26.14 |
| pH | 6.2-8.2 | 7.2 | 6.8-8.0 | 7.4 | 6.7-8.0 | 7.3 |
| Transparency(cm) | 5.0-198.5 | 49.23 | 20.0-266.0 | 109.75 | 16.0-249.0 | 132.5 |
| DO (ppm) | 3.2-12.2 | 7.08 | 2.4-16.0 | 7.0 | 2.0-16.0 | 6.75 |
| Free CO ₂ (ppm) | 1.6-16.0 | 3.18 | 2.0-6.0 | 3.07 | 2.0-6.0 | 3.14 |
| Totalalkalinity (ppm) | 10.0-36.0 | 23.15 | 18.0-28.0 | 22.0 | 10.0-26.0 | 22.28 |
| Phosphate (ppm) | Traces-0.48 | 0.36 | Traces | - | Traces | - |
| Chlorides (ppm) | 4.0-14.0 | 8.80 | 6.0-15.0 | 9.36 | 6.0-17.5 | 10.78 |
| Silicates (ppm) | 2.5-35.0 | 11.09 | - | - | - | - |
| Hardness (ppm) | 60.0-300.0 | 130.42 | 44.0-240.0 | 101.45 | 52.0-140.0 | 97.00 |
| Sp. Conductivity (micro-mhos) | 50.0-84.25 | 57.78 | 45.0-67.0 | 56.12 | 38.5-79.1 | 55.14 |
| Total dissolved solids (ppm) | 23.90-42.10 | 27.64 | 22.2-33.3 | 30.64 | 19.2-39.9 | 27.50 |

1) Water temperature (°C)

Water temperature ranged from 17.0 to 30.8 (av. 24.78) in the lentic zone. The minimum temperature was recorded in winter (December) while maximum in the month of April. In the intermediate sector it ranged from 22.5 to 31.0 (26.42) being minimum in

December and maximum in April. In the lotic sector it ranged from 21.3 to 31.0 (26.14) being minimum in January and maximum in May.

ii) *pH (Hydrogen ion concentration)*

Hydrogen ion concentration ranged from 6.2 to 8.2 (7.2) in the lentic sector. The minimum values were recorded in March while the maximum was in January. In the intermediate sector, it ranged from 6.8 to 8.0 (7.4). In the lotic sector it ranged from 6.7 to 8.0 (7.3) the minimum and maximum values were as in the lentic sector.

iii) *Transparency (cm)*

Transparency ranged from 5.0 to 198.5 (49.23) in the lentic sector. Low values were recorded during July and August while the high values in October/January. In the intermediate sector it ranged from 20.0 to 266.0 (109.75) and ranged from 16.0 to 249.0 (132.5) in the lotic sector of the reservoir. The low values were recorded during the months of July and August (Monsoon months) might be due to heavy rains, winds of high velocity. The high values were recorded from January to May and again from October to December probably due to low and moderate velocity of winds.

iv) *Dissolved oxygen (ppm)*

Dissolved oxygen ranged from 3.2 to 12.2 (7.03) in the lentic sector. The maximum and minimum values were recorded in May and October. In the intermediate sector it ranged from 2.4 to 16.0 (7.0) maximum and minimum being in April and October. In the lotic sector it ranged from 2.0 to 16.0 (6.75) maximum and minimum were as lentic sector.

v) *Free carbondioxide (ppm)*

Free carbondioxide ranged from 1.6 to 16.0 (3.18) in the lentic sector. The maximum value was recorded in January while the minimum was in the month of September. In the intermediate and lotic sectors it ranged from 2.0 to 6.0 (3.1) the maximum and minimum values were as in the lentic sector.

vi) *Total alkalinity(ppm)*

Total alkalinity ranged from 10.0 to 36.0 (23.15) in the lentic sector, the maximum values were recorded in July while the minimum was in December. In the intermediate

sector it ranged from 18.0 to 28.0 (22.0) being maximum in May and minimum in December. In the lotic sector it ranged from 10.0 to 26.0 (22.2) being maximum during May and minimum in January. The value of total alkalinity was always very poor in all the three sectors of the reservoir. This might have a direct bearing on the productivity.

vii) *Phosphate (ppm)*

Phosphates ranged from traces to 0.48 (0.36) in the lentic sector. The maximum values were recorded in July/August but other seasons no trend was observed. Similar situation prevailed in the other sectors also.

viii) *Chlorides (ppm)*

Chlorides ranged from 4.0 to 14.0 (8.8) in the lentic sector, the maximum value was recorded in July while the minimum was in April/May. In the intermediate sector it ranged from 6.0 to 15.0 (9.36) being maximum in August and minimum in March. In the lotic sector it ranged from 6.0 to 17.5 (10.78) being maximum in June and minimum in March.

Silicates (ppm)

In the lentic sector silicates ranged from 2.5 to 35.0 (11.09) being maximum in March and minimum in July.

ix) *Total hardness (ppm)*

Total hardness ranged from 60.0 to 300.0 (130.42) in the lentic sector being maximum in July while minimum in December. In the intermediate sector it ranged from 44.0 to 240.0 (101.45) being maximum in July and minimum in June. In the lotic sector it ranged from 52.0 to 140.0 (97.0) being maximum in January and minimum in June.

x) *Specific conductivity (micro-mhos)*

Specific conductivity ranged from 50.0 to 84.25 (57.78) in the lentic sector being maximum in March and minimum in October. In the intermediate sector it ranged from 45.0 to 67.0 (56.12) being maximum in January and minimum in June. In the lotic sector it ranged from 38.5 to 79.1 (55.14) being maximum in December and minimum in July.

xi) Total dissolved solids (ppm)

Total dissolved solids ranged from 23.90 to 42.10 (27.64) in the lentic sector, maximum being during March and minimum in October. In the intermediate sector it ranged from 22.2 to 33.3 (30.64) being maximum in January and minimum in June. In the lotic sector it ranged from 19.2 to 39.9 (27.5) being maximum in December and minimum in July.

A perusal of the above mentioned parameters is indicative of low values of total alkalinity, and specific conductivity while the other values are favourable.

Thermal stratification

Depth-wise sampling of water temperature did not give any indication of existence of thermocline. This probably was due to the heavy wind action resulting in the constant mixing of the waters in the reservoir.

Diurnal variation and Chemical stratification

Diurnal variation of physico-chemical conditions of water in the lentic sector is presented in Table IX. Dial studies for 24 hours at intervals of 2 hrs in lentic zone during summer and winter were carried out. There was no marked variation. Depth-wise analysis of water in the lentic sector of the reservoir is presented in Table X. Depth-wise analysis of dissolved oxygen, free carbondioxide, specific conductivity, total dissolved solids, total alkalinity and pH did not show any marked variation.

Primary productivity

Monthly variation in primary production ($\text{mgC}/\text{m}^3/\text{day}$) of Bhatghar reservoir from 1987 to 1992 are presented in Table No. XI. The average gross primary production varied from 20.83 to 145.80 with average of 71.20 while the net production varied from 10.42 to 83.33 (40.39). The overall average for gross production 71.20 and net production was 40.39. Studies by ^{14}C technique revealed a low energy fixation value of $467.15 \text{ Cal}/\text{m}^2/\text{day}^{-1}$. The higher value was found to be $6632.28 \text{ Cal}/\text{m}^2/\text{day}^{-1}$ resulting in average of $5375.0 \text{ Cal}/\text{m}^2/\text{day}^{-1}$. Thus the expected yield is 65 kg/ha with an average growth rate of 0.50 kg for each of the species stocked, the stocking rate when computed will be 250 numbers per hectare.

Table IX . Diurnal variation in the lentic sector of Bhatghar reservoir

| Season | Hrs. | Air temp. (°C) | Water temp. (°C) | pH | Cond. umhos | TDS ppm | DO ppm | CO ₂ ppm | Alk. ppm | Chloride ppm |
|--------|------|----------------|------------------|-----|-------------|---------|--------|---------------------|----------|--------------|
| Summer | 6.0 | 27.6 | 27.3 | 7.7 | 47.3 | 23.6 | 2.8 | 2.0 | 26.0 | 20.0 |
| | 10.0 | 31.8 | 28.3 | 7.4 | 56.8 | 28.6 | 2.6 | 2.0 | 28.0 | 24.0 |
| | 14.0 | 30.3 | 29.3 | 7.4 | 56.5 | 28.4 | 2.2 | 6.0 | 26.0 | 38.0 |
| | 18.0 | 27.4 | 27.7 | 7.4 | 59.2 | 29.8 | 2.4 | 2.0 | 26.0 | 28.0 |
| | 22.0 | 28.2 | 26.4 | 7.4 | 56.6 | 28.5 | 2.8 | 10.0 | 28.0 | 32.0 |
| Winter | 16.0 | 31.0 | 27.7 | 8.3 | 62.2 | 32.1 | 11.2 | 2.0 | 36.0 | 8.0 |
| | 18.0 | 26.2 | 25.8 | 7.8 | 64.1 | 32.2 | 11.2 | 4.0 | 30.0 | 8.0 |
| | 20.0 | 26.7 | 24.9 | 7.8 | 51.2 | 25.9 | 9.6 | 4.0 | 24.0 | 8.0 |
| | 22.0 | 24.4 | 23.3 | 7.8 | 50.0 | 25.1 | 8.8 | - | 44.0 | 12.0 |
| | 24.0 | 20.9 | 23.5 | 7.4 | 49.4 | 24.8 | 7.6 | 4.0 | 22.0 | 6.0 |
| | 02.0 | 22.4 | 22.5 | 7.4 | 44.4 | 22.3 | 5.6 | 4.0 | 18.0 | 8.0 |
| | 04.0 | 20.0 | 22.1 | 7.4 | 44.0 | 22.0 | 5.2 | 6.0 | 18.0 | 8.0 |
| | 06.0 | 19.4 | 21.2 | 7.8 | 43.3 | 20.6 | 6.0 | - | 24.0 | 8.0 |
| | 08.0 | 24.4 | 22.7 | 7.8 | 50.8 | 25.7 | 7.6 | 6.0 | 28.0 | 8.0 |
| | 10.0 | 26.1 | 25.4 | 7.8 | 49.2 | 24.7 | 7.2 | 4.0 | 20.0 | 10.0 |
| | 12.0 | 27.3 | 27.6 | 7.2 | 61.6 | 31.2 | 10.8 | 6.0 | 20.0 | 6.0 |
| | 14.0 | 28.5 | 27.1 | 7.4 | 59.2 | 29.8 | 10.0 | 4.0 | 18.0 | 6.0 |

Table X. Chemical stratification of Bhatghar reservoir

| Depth (m) | Air temp. (°C) | Water temp. (°C) | pH | Cond. (mmhos) | TDS (ppm) | DO (ppm) | CO ₂ (ppm) | Alk. (ppm) |
|-----------|----------------|------------------|-----|---------------|-----------|----------|-----------------------|------------|
| 1.0 | 24.3 | 26.5 | 7.3 | 58.2 | 29.1 | 8.4 | 4.0 | 16.0 |
| 2.0 | 24.3 | 26.1 | 7.3 | 63.2 | 31.6 | 8.4 | 2.0 | 16.0 |
| 3.0 | 24.3 | 26.1 | 7.3 | 64.6 | 27.5 | 8.8 | 2.0 | 18.0 |
| 3.0 | 24.3 | 25.3 | 7.3 | 63.5 | 31.9 | 7.1 | 2.0 | 18.0 |

Table XI. Monthly variation in Primary production (mgC/m³/day) of Bhatghar reservoir (1987-92)

| MONTHS | GROSS PRODUCTION | NET |
|------------------|------------------|-------|
| <i>January</i> | 104.16 | 83.33 |
| <i>February</i> | 41.66 | 20.83 |
| <i>March</i> | 83.33 | 20.83 |
| <i>April</i> | 68.58 | 46.85 |
| <i>May</i> | 104.17 | 62.50 |
| <i>June</i> | 41.66 | 26.03 |
| <i>July</i> | 20.83 | 10.42 |
| <i>August</i> | 31.25 | 20.80 |
| <i>September</i> | 67.71 | 52.50 |
| <i>October</i> | 36.47 | 26.04 |
| <i>November</i> | 145.80 | 52.08 |
| <i>December</i> | 108.81 | 62.50 |

BIOTIC COMMUNITIES

Bottom biota

Bottom organisms were collected through Ekman dredge from the bottom using sieve No. 40 in all the sectors of the reservoir. No benthic macrofauna was present in any of the sectors in any of the seasons. Red gravelly substratum of the reservoir in its entire stretch does not offer any sustenance for any bottom biota.

The reservoir has no aquatic vegetation in any of the sectors and any season

Plankton

Lentic sector

The plankton production of lentic zone ranged from 8 ul⁻¹ in August to 6601 ul⁻¹ in June 1990 and from 80 ul⁻¹ in August to 1142 ul⁻¹ in March 1991. Four peaks were observed in plankton density, (two in summer, one in post-monsoon and one in winter)

during 1990 (Fig. 2). While three peaks were observed one in March, one in summer and one in winter. On an average phytoplankton formed 87.25%, zooplankton 12.75% of the total planktonic organisms.

Trends of phytoplankton during 1990

(Fig. 3)

Chlorophyceae: This group formed 29.75% of the total planktonic population and was mainly represented by *Gonatozygon* sp., *Hormidium* sp., *Eudorina* sp., *Closteridium* sp. And *Kirchneriella* sp. Maximum density of this group was observed in November (84.09%) and minimum in September (4.47%).

Myxophyceae: This was the most dominant group among phytoplankters and formed 36.14% of the total plankton population. Three pulses, first in April (87.54%), second in June (94.16%) and third in December in lesser magnitude were observed. Dominant forms were *Anacystis* sp. and *Gomphosphaerium* sp.

Bacillariophyceae: This group ranks third in order of abundance and its percentage ranged from 0.65 in June to 92.74 in September. On an average it constituted 12.95% of the total plankton population. Two pulses, one in September and other in January, were witnessed. Dominant forms were *Navicula* sp., *Nitzschia* spp., *Synedra* sp. and *Surirella* sp.

Desmidiaceae: This group formed 2.98% of the total planktonic population and was mainly represented by *Staurastrum* sp. Desmids were absent during June to September and its percentage fluctuated from 6.67 in December to as low as 2.27 in November.

Dinophyceae: This group ranked fifth in order of abundance and was absent during June to October and December. Highest occurrence was observed during January (16.17%). On an average, it constituted 1.87% of the total plankton population. The dominant form was *Ceratium* sp.

Zooplankton

Rotifera: This group ranked second in order of abundance among zooplankters and formed, on an average 5.95% of the total plankton. A peak in their production was observed in March (63.41%) followed by October (44.44%) and July (27.27%) (Fig. 4). This group was absent during August-September. Dominant forms were *Keratella* sp., *Brachionus* sp., *Asplanchna* sp., and *Cephalodella* sp.

Cladocera: This group ranked third in order of abundance among zooplankters and formed, on an average, 1.54% of the total plankton. It was most abundant in August (50%) followed by May (18.75%) and December (11.76%). The group was absent during July and September to November. The dominant forms were *Chydorus* sp., *Bosmina* sp., *Diaphanosoma* sp. and *Bosminopsis* sp.

Copepods: This was the most dominant group among the zooplankters and formed, on an average, 7.99% of the total plankton. It was most abundant in January (69.53%) followed by April (39.13%) and July (72.73%). The group was not found during August to September in the samples. The dominant forms were *Diaptomus* sp., *Cyclops* sp., and their larvae (*Nauplii*).

Protozoa: Represented by *Actinophrys* sp., *Heterophrys* sp. and *Arcella* sp., Protozoa, on an average, formed 0.83% of the total plankton. It was abundant during September (100%) followed by March (9.76%) and May (12.50%). The group was absent during January, July and October-November.

Plankton during 1991

During 1991, phytoplankton formed 90.81% of the total planktonic population where a decline in *Bacillariophyceae* and *Mixophyceae* population were clearly discernable, while *chlorophyceae* remained more or less stable. However, an increase in Desmids and *Dinophyceae* were noted. Among zooplankters, rotifers, cladocerans, copepods registered a definite decline in their population, the protozoans were totally absent in the population when compared to that of 1990.

Intermediate sector

The average plankton quantity from the intermediate zone was 110 u/l. Phytoplankton comprised of *Navicula*, *Gonatozygon*, *Microspora*, *Spirogyra*, *Nitzschia*, *Diatoma*, *Rhopalodia*, *Mougeotia*, and *Lingbya*. Zooplankton was represented by copepods and cladocerans, the species being *Cyclops*, *Bosminopsis*, *Pleuroxux*, *Centropyxis*, and larvae of copepods (*Nauplii*). During 1991, total plankton ranged between 60 ul⁻¹ in July to 802 ul⁻¹ in April. *Chlorophyceae* was predominant followed by Desmidaceae. Dominant forms were *Protococcus*, *Gonatozygon*, *Anacystis*, *Coelosphaerium*, *Staurastrum*, *Cosmarium*, *Ankistrodesmus*, *Hormidium* and *Synedra*. Zooplankton was dominated by *Keratella*, *Nauplius*, *Chydorus*, *Filinia*, *Pleuroxus* and *Bosminopsis*.

Lotic zone

During 1991, the total plankton varied between 100 μl^{-1} in July to 1201 μl^{-1} in April. Phytoplankton dominated over zooplankton. The phytoplankton was dominated by *Chlorophyceae* and followed by *Desmidaceae*. Dominant forms were similar to that of intermediate zone. Other forms encountered were *Haxarthra*, Belloids group and *Pediastrum*.

Periphyton

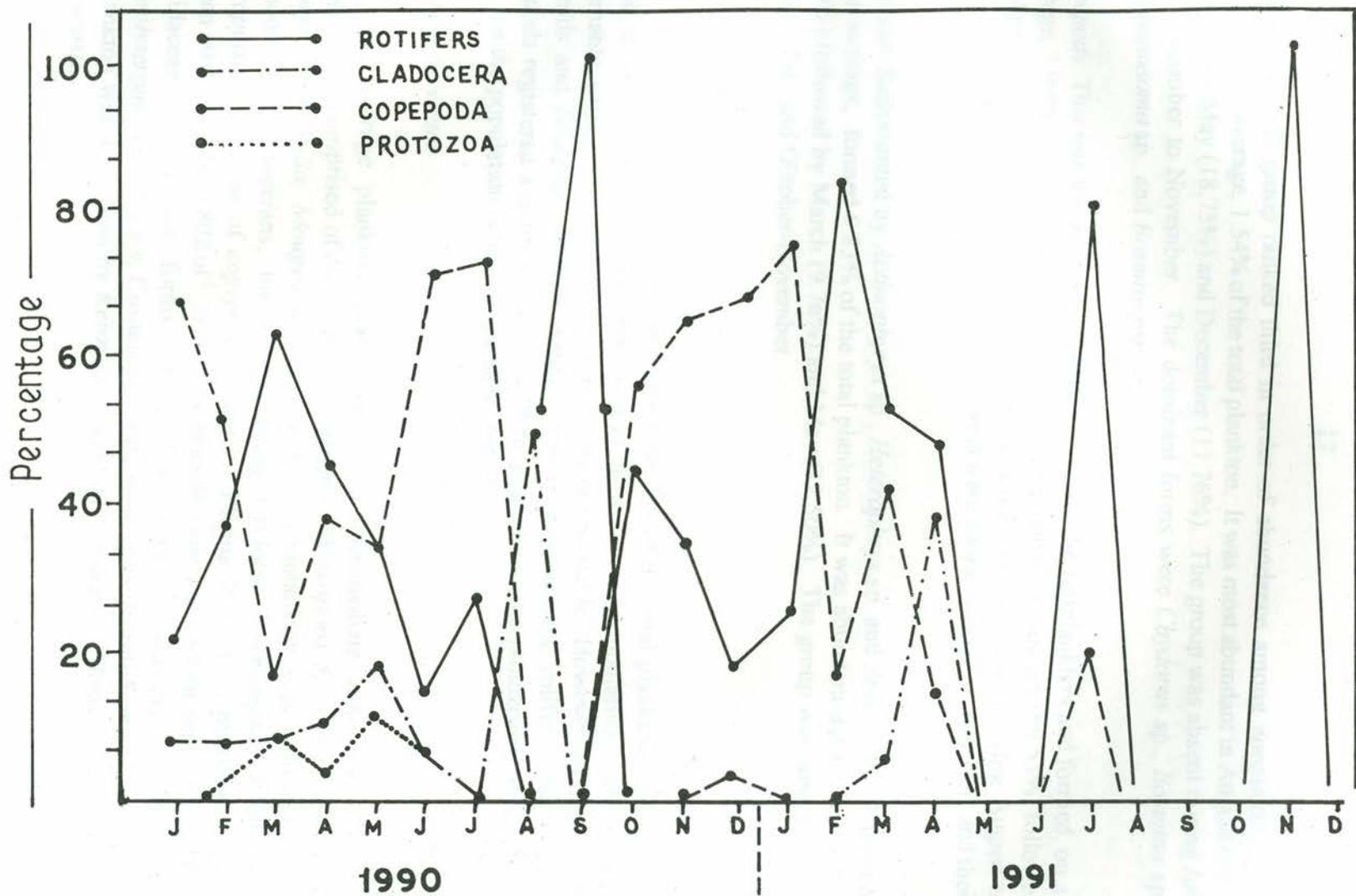
The periphytic communities mostly comprised *Bacillariophyceae* (20 genera) followed by *Chlorophyceae* (14 genera), *Myxophyceae* (5 genera), *Desmidaceae* (3 genera) and *Dinophyceae* (1 genus). The following is the list of periphytic organisms encountered in Bhatghar reservoir.

| | | |
|-------------------|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BACILLARIOPHYCEAE | : | <i>Diatoma, Synedra, Eucoconeis, Fragilaria, Navicula, Cocconeis, Surirella, Nitzschia, Amphora, Frustulia, Diploneis, Stauroneis, Gyrosigma, Epithema, Cymbella, Asterionella, Tabellaria, Rhopalodia, Mastogloea, Gomphonema.</i> |
| CHLOROPHYCEAE | : | <i>Spirogyra, Nostoc, Pediastrum, Closteridium, Ankistrodesmus, Gonatozygon, Westella, Mougeotia, Hormidium, Genticularia, Microspora, Syndesmus, Protococcus, Natrium.</i> |
| MYXOPHYCEAE | : | <i>Anabaena, Microcystis, Phormidium, Merismopedia, Oscillatoria.</i> |
| DESMIDACEAE | : | <i>Cosmarium, Staurastrum, Euastrum</i> |
| DINOPHYCEAE | : | <i>Ceratium</i> |

Fish fauna

Fish encountered both in the commercial and experimental fishing indicated the presence of 49 species belonging to 30 genera and 12 families are presented in Table XII. The classification adopted was that of Menon (1974) and Jhingran (1975).

Fig. 4 Percentage composition of different groups of zooplankton



COMMERCIAL FISHING

While Bhatghar reservoir came into existence ever since 1928, the fishing was carried out only by the local fishermen from the adjoining villages. There is no exclusive fishermen village. Active fishermen do the fishing and sell the produce at the village itself. However, the state fisheries department has introduced the system of licensing commercial nets. The commercial nets are in the form of gill nets (20 mm to 150 mm) operated all through the year in all the sectors. During summer months (March-June) drag nets are operated in small pockets in the lentic and some times in intermediate sectors of the reservoir.

The State Fisheries Department has leased the reservoir to Gajanan Fisheries Cooperative Society, Bhor with rights to fish in the reservoir with membership of 120, the society has been doing fishing since 1986. However, the society is not in a position to stock the reservoir because of monetary reasons. The intensity of fishing in the lentic sector only and to a limited extent in the intermediate sectors. Even though the State Fisheries Department is stocking the reservoir since 1979-80, there is no record of fish landings available with the department. Catch structure of Bhatghar reservoir is presented in Fig. 5 and 6

Fishing units

Commercial fishing in Bhatghar reservoir is conducted by nylon gill nets. The net is without foot rope and has floats made up of thermocol. The net has a mesh-bar range of 20 mm- 150 mm. The fishing unit consists of two fishermen and ten to fifteen gill nets of different mesh bars. No boats are used for fishing in the reservoir excepting a single fisherman of the lentic zone who is in possession of a mechanised boat.

Yearly variations in fish yield

The total fish production from the reservoir was estimated to be 24506.75 kg (1987). The production decreased onwards 12721.5 kg (1988), 9278.88 kg (1989) and 8999.05 kg (1990). It showed an increase in 1991 (12099.5 kg). The average production was 13521.14 kg from the reservoir during the entire period of investigation. The details are presented in Table XIII.

Performance of individual species

Catla catla: The total catch of *C. catla* varied between 25.87 kg (1989) and 441.0 kg (1980). The average yield was 213.98 kg (1.58%) for the period 1987-1991. The maximum catch 441.0 kg in 1990 and 420.0 kg in 1991 were observed due to the stocking of the reservoir during 1989.

Labeo rohita: The total yield of *L. rohita* was lowest among the major carps recorded during 1987 (9 kg) and 1988 (17 kg). The average production was 5.20 kg (0.04%).

Cirrhinus mrigala: The total catch of *C. mrigala* was highest amongst the major carps with an average of 345.01 kg (2.55%). The total yield ranged between 155.04 kg (1989) to 729.0 kg (1988).

Tor khudree: The total of *T. khudree* varied between 16.00 kg (1990) to 1023.95 kg (1989). The average catch was 314.84 kg (2.33%).

Puntius dobsonii: *Puntius dobsonii* occurred in the catches during the years 1987-89 only. The yield ranged from 143.50 kg (1989) to 441.15 kg (1989). The average yield was 202.33 kg contributing to 1.50% towards the total production.

Wallago attu: The total catch of *W. attu* was 368.25 kg during 1987. It showed an increasing trend during 1988 (1126.00 kg) and 1989 (1439.8 kg). Thereafter the catch declined to 194.5 kg (1990) and again increased in 1991 (3175.5 kg). It formed Vth in rank in the order of abundance in the total fish yield. The average was 689.21 kg contributing to 5.10% towards the total fish yield.

Puntius kolus: *P. kolus* abundant being 2nd in rank in occurrence of the total yield. While the minimum catch was in the year 1990 (1019 kg), the maximum was in the year 1987 (9574 kg). The average yield was estimated to be 3857.74 kg contributing to 28.55% towards the total fish catch.

Cirrhinus fulungee: *C. fulungee* was dominant form with average of 3934.3 kg contributing to 36.43% in the total fish yield of the reservoir. The catch ranged from 4254.47 kg (1989) to 10726.0 (1987).

Chela spp.: *Chela* was recorded to contribute 2930 kg during 1987. It dwindled from the catches during the years 1988 and 1989, to come up again during 1990 (3095 kg) and 1991 (3383 kg). The average was 1841.6 kg contributing to 13.62% towards the total fish yield.

Fig. 2 Month-wise abundance of plankton

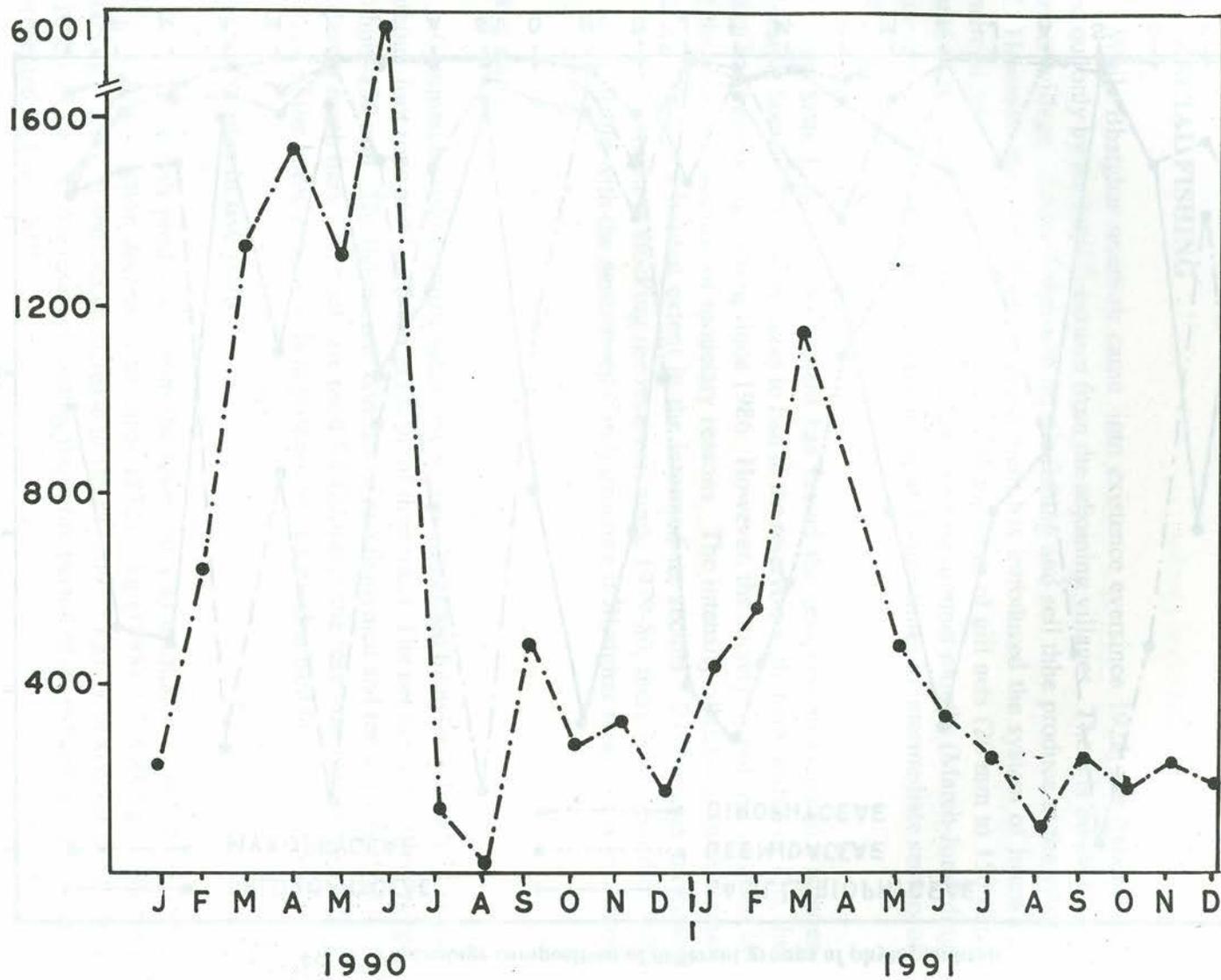
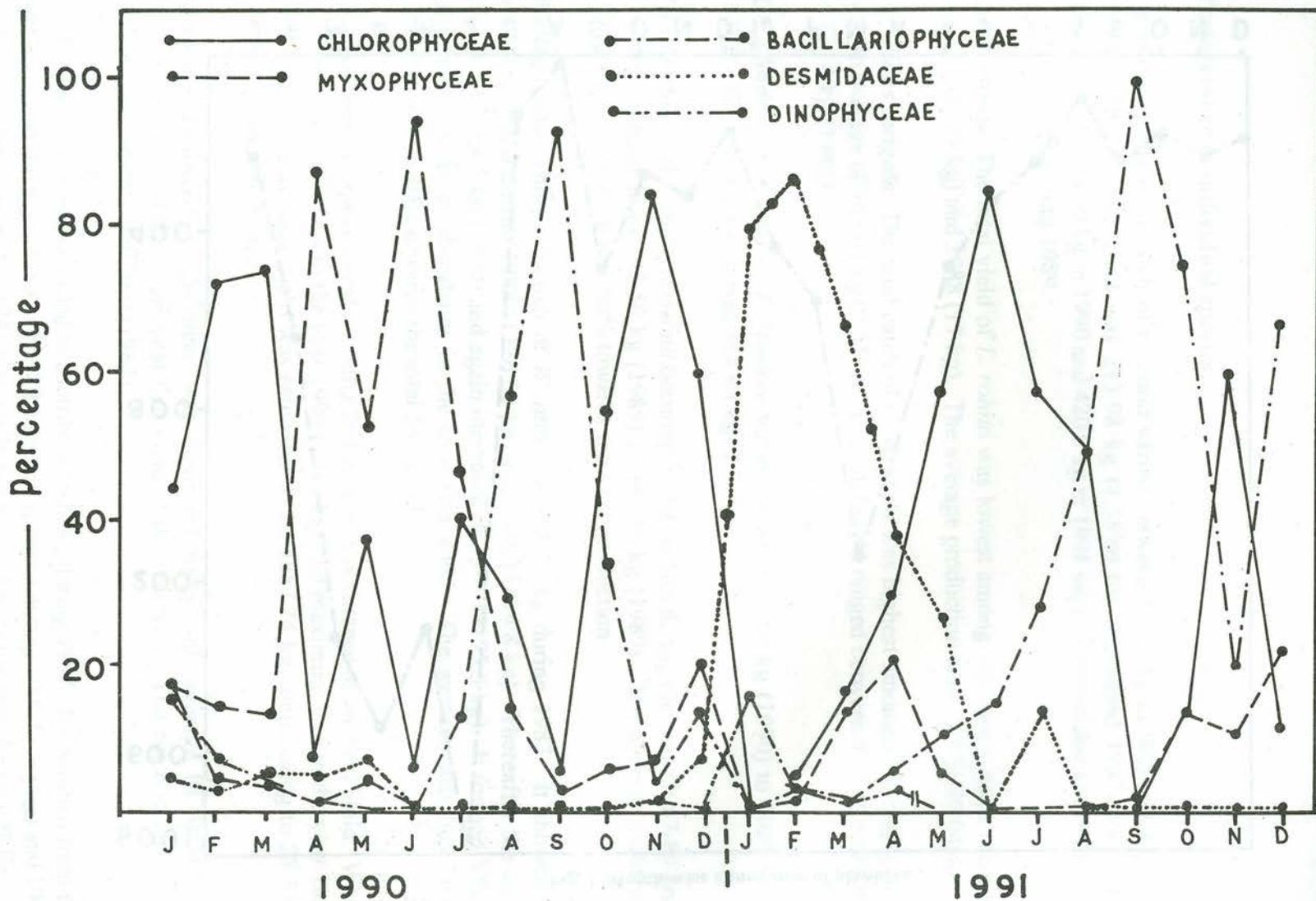


Fig. 3 Percentage composition of different groups of phytoplankton



Eels: Eels contributed little towards the total fish yield of the reservoir. The average was only 48 kg contributing to 0.35% of the total yield.

Murrels: The total catch of murrels ranged from nil (1989) to 485 kg (1991). The average was estimated to be 132.5 kg contributing only 0.58% of the total.

Mugil sp.: *Rhinomugil corsula* is non-indigenous species to the reservoir. It was said to have gained entry into the reservoir at the time of stocking the same with seed brought from Calcutta. Its catch is however negligible with an average of 3.4 kg and a percentage contribution of 0.03 to the total fish yield of the reservoir.

Others: Others comprising species like loaches, *Ambassis* etc. were abundant during 1990 (2200 kg) and 1991 (2398 kg). Their average estimated to be 932.98 kg (6.90%).

Catch per unit effort

Commercial gill nets with a mesh bar range of 20 mm to 150 mm were sampled for catch per unit effort. Table XIV gives the details :

Table XIV. Catch per unit of effort in Bhatghar reservoir

| Year | No. of units | Total catch (kg) | catch/unit/effort (kg/day) |
|------|--------------|------------------|----------------------------|
| 1988 | 112 | 116.75 | 1.048 |
| 1989 | 259 | 263.92 | 0.913 |
| 1990 | 146 | 357.65 | 2.449 |
| 1991 | 88 | 156.77 | 1.238 |

The average catch per unit effort was estimated to be 1.092 kg/day.

Fishery biology

i) Length-weight relationship

The length-weight relationship of the following commercial species of fish from the reservoir were estimated and are as follows :

- a) *Tor khudree* $\log W = -6.5968 + 3.6278 \log L$ ($r=0.970$)
 b) *C. mrigala* $\log W = -6.0333 + 3.3630 \log L$ ($r = 0.989$)

- c) *Osteobrama vigorsii* $\log W = -2.1535 + 1.7819 \log L$ ($r = 0.889$)
 d) *Puntius kolus* $\log W = -7.4083 + 4.0330 \log L$
 e) *Osteobrama cotio cotio* $\log W = -4.1470 + 2.5616 \log L$ ($r=0.742$)

BIOLOGY OF FISHES

Food and feeding habits

Qualitative analysis of gut contents of commercially important carps from the reservoir revealed the following items :

- i) *Puntius kolus* : *Epithemia, Amphora, Surirella, Synedra, Tabellaria, Diatema, Eudorina, Spirogyra, Diploneis, and Mastogloea.*
 plant seeds and sand was also noticed occasionally.
 ii) *Chela spp.* : *Microcystis, Synedra, Tetraspora, Spirogyra, Navicula, Diatoma, rotifers and copepods.*
 iii) *Catla catla* : *Pinnularia, diatoms and detritus*
 iv) *C. fulungee* : *Tabellaria, Navicula, Cosmarium, Epithemia, Synedra, Amphora, Spirogyra, and Euastrum etc.*

Breeding biology

Fecundity in relation to the body weight and gonad weight of *Osteobrama cotio cotio* was estimated. The relative fecundity ranged between 395-575 number of eggs while the absolute fecundity ranged between 2110-5352. Fecundity of *Cirrhinus fulungee* was estimated to be 7369 eggs/gm.

These studies could be initiated during 1988 season only. The shooting net operation from Pasure creek (Intermediate zone) revealed the occurrence of fingerlings of *C. mrigala* and *C. fulungee* at a distance of about 12 km from the dam site. Oozing males and spent females were encountered in the gill net catches both from nearer the dam site and the lotic zone of the reservoir.

STOCKING OF THE RESERVOIR

As per the records of the Dept. of Fisheries, Govt. of Maharashtra, Bhatghar reservoir has been stocked annually with fish seed (fry) brought from Calcutta from the year 1979 onwards. Year-wise stocking figures are as follows :

| | | |
|---------|-------|--------------------|
| 1979-80 | ..... | 1 lakh |
| 1980-81 | ..... | 4.82 lakhs |
| 1981-82 | ..... | Nil |
| 1982-83 | ..... | Nil |
| 1983-84 | ..... | 1000 fingerlings |
| 1984-85 | ..... | 5000 fingerlings |
| 1985-86 | ..... | 10,000 fingerlings |
| 1986-87 | ..... | 25,000 fingerlings |

Fry of *Tor khudree* (5,000 numbers) obtained from Tata Electric Co. Lonavala were stocked by this unit during September, 1987. About 2.25 lakhs of fingerlings ranging between 65 mm- 110 mm size of major carps (*C. catla* 50%, Rohu 30% and Mrigal 20%) were stocked during the period August/September 1988. Continued stocking by the Fisheries Department did not have an impact on the revival of the fishery probably due to the size at the time of stocking, the stocking of 2.25 lakhs of fingerlings during 1988 did show a marked improvement in the landings especially of *C. catla* and mahseer during 1989 (Fig. 7).

CONCLUSIONS AND RECOMMENDATIONS

Based on limnological investigations of Bhatgar reservoir conducted by Central Inland Capture Fisheries Research Institute, Barrackpore from 1987 to 1992, the reservoir was found to be low productive with an annual yield varying from 8999.05 kg (1990) to 24506.75 kg (1989) giving an average of about 4.83 kg/ha.

Though the reservoir has faunistic diversity of 49 species, the overall percentage of major carps comprising *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Tor khudree* and *Puntius dobsonii* is phenomenally low (Range : 4.20% to 17.73% of total catch) very minor carps are the most dominant (Range : 64.72% to 93.97%). Catfish population with species like *Wallago attu*, *Mystus seenghala*, *Mystus cavasius*, *Ompok bimaculatus* and *Silondia* sp. have shown a spurt in the years 1988 and 1989.

The characteristic feature of the reservoir ecosystem was high and sudden yearly fluctuations in the water level ranging from 24 to 32 m during the period of study. All biotic communities of the reservoir, essential to increase its fish productivity are in their lowest ebb during the months of maximum level fluctuations. A comparatively stable reservoir level is more conducive to growth of organisms.

As seen from physico-chemical analysis of reservoir soil, it was found to be sandy (48 to 68%) with poor levels of organic carbon (0.38%), available phosphorus (1.98 mg/100 g) and available nitrogen (18.65 mg/100 g) against the normal values of latter three parameters being 0.5%, 3.0 mg/100 g and 25.0 mg/100 g respectively.

Some of the limno-chemical parameters of water like total alkalinity (22.38 mg l⁻¹), phosphate (Traces), total dissolved solids (27.5 mg l⁻¹) and specific conductivity (55.14 micro mhos/cm) also indicated poor productivity of the lake. The reservoir due to its constant flowing condition of water and high wind velocity, could not exhibit thermal or chemical stratification, the productive characters of water body.

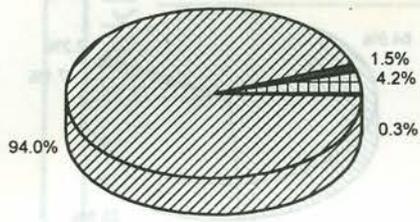
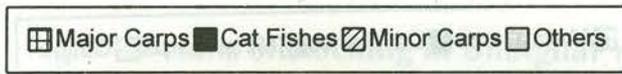
The most important vehicles of input of allochthonous organic matter into water bodies are streams, surface run-off, ground water, shore erosion, litter fall, municipal and industrial wastes and atmospheric precipitation. Detritus in the form of dead leaves is the most conspicuous and frequently studied input of allochthonous particulate organic matter. The studies of Bhatgar reservoir showed that organic matter of its soil is very poor and the energy brought in through allochthonous source is inadequate. Under these circumstances, the energy stored in the reservoir was limited only through solar radiation and autochthonous source.

Because of limitations of organic matter and other morphometric characters of the reservoir, the biotic communities like benthos and macrophytes are also absent. Lack of organic detritus in the reservoir substratum as evidenced by the total absence of bottom biota and absence of macro-vegetation have affected the establishment of bottom feeders like *C. mrigala* and browsers like *L. rohita*.

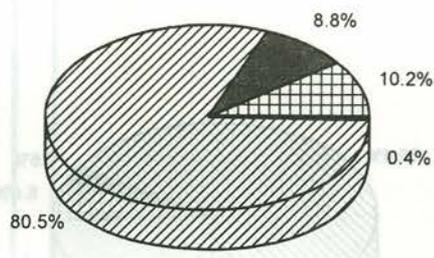
The relative abundance of plankton as primary producers in the reservoir indicates its productive nature. However, due to the meagre percentage of major carp population, their low breeding success and consequent autostocking, the primary producers are utilised fully by the minor carps like *C. fulungee*, *P. kolus* and *Salmostoma* spp. resulting their abundance.

The natural recruitment of major carps is either absent or poor due to non-availability of suitable breeding grounds in lotic sector of the reservoir or on account of inadequacy of water inflow at the right time. Therefore, the reservoir needs regular stocking support of major carp fingerlings. The stocking done earlier before 1984-85 was probably with small sized fry on account of which it could not reflect in commercial fishery. This trend was later reversed to some extent with stocking of big sized fingerlings only from 1984-85.

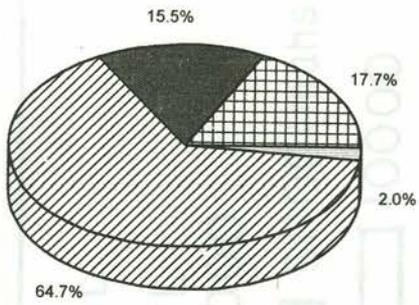
Fig. 5 Fish catch composition of Bhatghar reservoir



1987

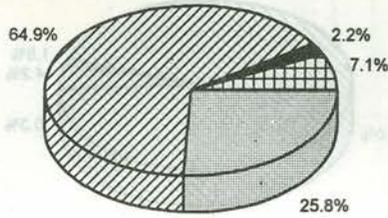
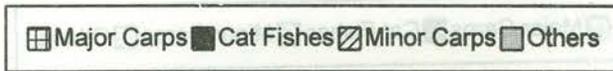


1988

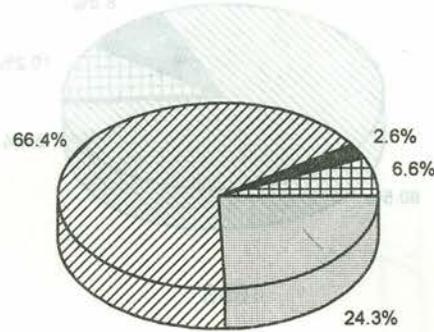


1989

Fig. 6 Fish catch composition of Bhatghar reservoir

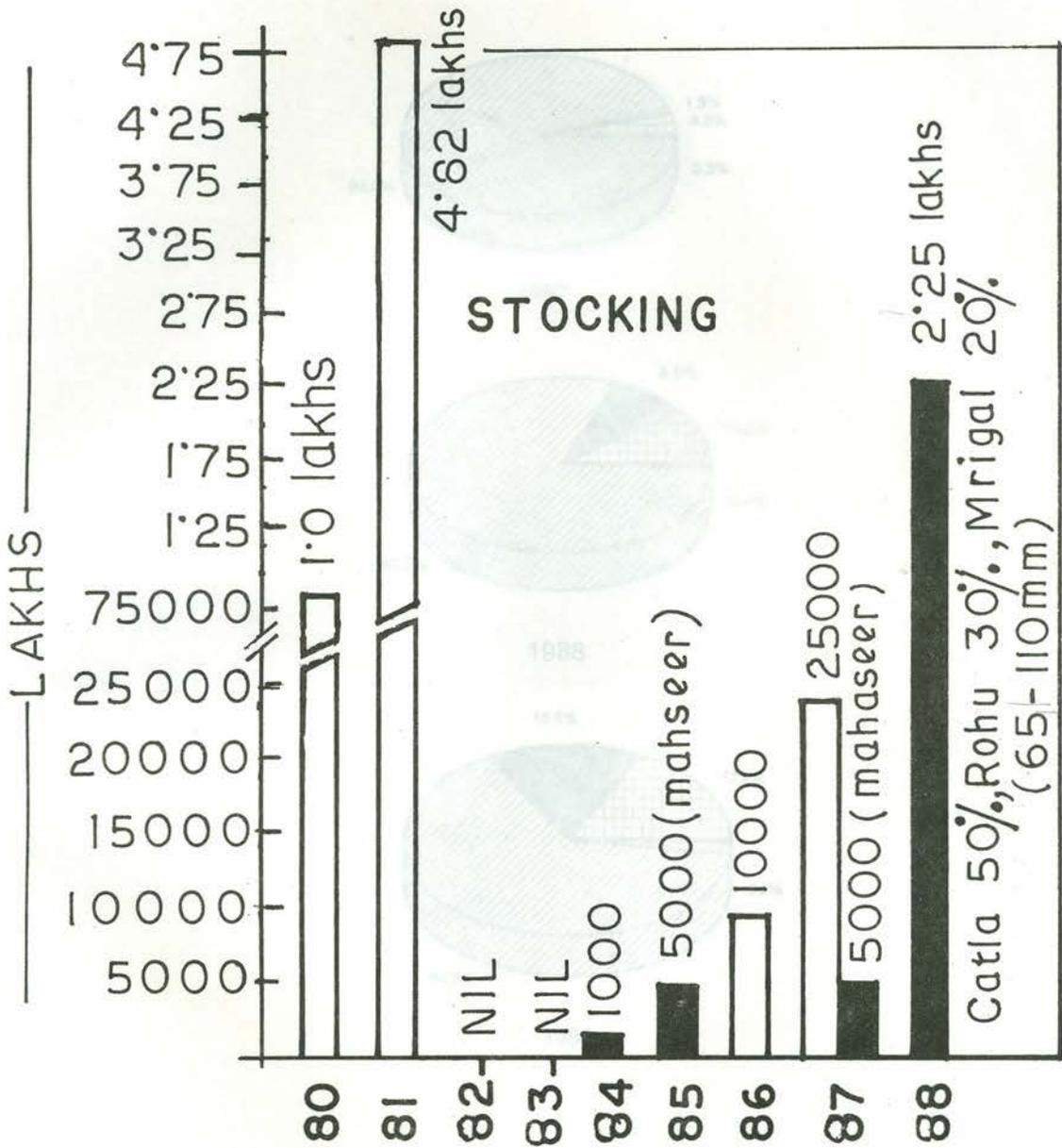


1990



1991

Fig. 7 Details of stocking in Bhatghar reservoir



The active fishermen fishing in Bhatghar reservoir are only 20 in number. There are no regular landing centres. Catch comes to the nearest village of the fishing area.

The reservoir is likely to give more fish yield than the present 4.8 kg/ha/yr which may be possible only with regular stocking of major carp fingerling @ 250 nos/ha/yr in the size range of 100-150 mm and ratio of catla 40, rohu 30, mrigal 30. In view of the availability of Tor khudree seed with the Tata Electric Co., Lonovola, the same could be stocked along with major carps to augment the dwindling species from its total disappearance.

The fishing effort of the reservoir is very poor which should be enhanced with organisation of more Fishermen Co-operative Societies to provide them nets, fishing boats, motor launch etc. as per their requirements. With formation of more fishermen societies, fish landing centres may also increase so as to record fish catch statistics more accurately. The fishermen, at the time of issuing them licences, may be categorically told to bring the catch daily to their earmarked fish assembly centres, failing which their licences would be forfeited. Drag net fishing should be conducted intensively to catch more of *Salmostoma* spp., which form an outstanding fishery in Tungabhadra reservoir (Karnataka).

The most unfavourable feature of the reservoir from a fisheries point of view is the complete withdrawal of water from the reservoir to facilitate cleaning process of hydel turbines, encountered every 2-3 years. This obviously results in undesirable level of fishing mortality. However, some management options can be thought of based on the experience of local State Fisheries Officers. Loss of fish stock can be prevented if the gates are provided with some kind of mesh filters to retain the fish. Hence, a tripartite meeting between the irrigation, power generation and fisheries officials must be called to solve this problem.

The fishing should be banned during July and August.

The present nursery beneath the dam near Malwadi village may be renovated to the fullest extent and put to use with immediate effect to rear and raise spawn of major carps to fingerlings size and release the same in the lotic region.

Table XII :List of fishes from Bhatghar reservoir

| Name of Species | Local Name | Zone | Season |
|---------------------------------------------------------------|------------|--------|--------------------------|
| Order : Clupeiformes Sub Order : Notoptereidei | | | |
| Family : Notopteteridae | | | |
| 1. <i>Notopterus notopterus</i> (Palls) | Chelat | Entire | Rare |
| 2. <i>Notopterus chitala</i> (Ham.) | Chelat | Entire | Rare |
| Order : Perciformes, Sub Order : Percoidei | | | |
| Family : Centropomidae | | | |
| 3. <i>Chanda nama</i> (Ham.) | Kachaki | Entire | All seasons |
| 4. <i>Chanda ranga</i> (Ham.) | Kachaki | Entire | All seasons |
| Order : Cypriniformes, Sub Order : Cyprineidei | | | |
| Family : Cyprinidae | | | |
| 5. <i>Salmostoma boeppia</i> (Day) | Amili | Entire | All seasons |
| 6. <i>S. Untrahi</i> (Day) | Vadshi | Entire | All seasons ⁷ |
| 7. <i>Rasbora elanga</i> (Ham.) | Khairi | Entire | All seasons ⁸ |
| 8. <i>R. daniconius</i> (Ham.)(Var. <i>Neilgherriensis</i>) | Dandavan | Entire | All seasons |
| 9. <i>Danio equipinnatus</i> (Mc. Clelland) | | Entire | All seasons |
| 10. <i>D. Devario</i> (Ham.) | Kavadasi | Entire | All seasons |
| 11. <i>Catla catla</i> (Ham.) | Katla | Entire | All seasons |
| 12. <i>Cirrhinus mrigala</i> (Ham.) | Mrigal | Entire | All seasons |
| 13. <i>C. Fulungee</i> (Sykes) | Loli | Entire | All seasons |
| 14. <i>Cyprinus carpio</i> (Linn.) (Var. <i>Communis</i>) | Carpio | Lentic | Rare |
| 15. <i>Garra lamta</i> (Ham.) | Mullya | Entire | Summer & winter |
| 16. <i>Labeo rohita</i> (Ham.) | Rohu | Lentic | -do- |
| 17. <i>Labeo calbasu</i> (Ham.) | Valvat | Lentic | -do- |
| 18. <i>Labeo sindensis</i> (Day) | Sand | Lentic | Rare |
| 19. <i>Labeo porcellus</i> (Heckel) | | Lentic | Rare |
| 20. <i>Hypophthalmichthys molitrix</i> (Val.) | Cnanderi | Lentic | Rare |
| 21. <i>Osteobrama cotio cotio</i> (Ham.) | Phek | Entire | Summer & Winter |
| 22. <i>Osteobrama vigorsii</i> (Sykes) | Rawas | Entire | All seasons |
| 23. <i>Osteobrama neilli</i> (Sykes) | Rawas | Entire | -do- |
| 24. <i>Rohtee ogilbii</i> (Sykes) | Rotee | Entire | -do- |
| 25. <i>Tor khudree</i> (Sykes) | Khadsi | Entire | -do- |
| 26. <i>Tor mussulah</i> (Sykes) | Khadsi | Lentic | Rare |
| 27. <i>Puntius kolus</i> (Sykes) | Kolshi | Entire | All seasons |
| 28. <i>P. Sophore</i> | Debri | Entire | -do- |
| 29. <i>P. ticto ticto</i> (Ham.) | Debri | Entire | -do- |
| 30. <i>P. sarana sarana</i> (Ham.) | Lalpari | Entire | -do- |
| 31. <i>P. Jerdoni</i> (Day) <i>P. Dobsonii</i> | Panghat | Lentic | Rare |
| 32. <i>P. subnastutus</i> (Val.) | Panghat | Lentic | Rare |
| 33. <i>P. Amphibius</i> (Val.) | Panghat | Lentic | Rare |

Family: Cobitidae

- | | | | | |
|-----|------------------------------------------|--------------|--------|------|
| 34. | <i>Nimachilus evazardi</i> (Van Hornell) | <i>Murra</i> | Lentic | Rare |
| 35. | <i>N. denisonii</i> (Day) | <i>Murra</i> | Lentic | Rare |
| 36. | <i>Nimachilichthys rueprel</i> (Day) | <i>Murra</i> | Lentic | Rare |

Order : Siluriformes**Family : Siluridae**

- | | | | | |
|-----|-----------------------------------|----------------|--------|-------------|
| 37. | <i>Ompok bimaculatus</i> (Bloch) | <i>Gugli</i> | Entire | All seasons |
| 38. | <i>Wallago attu</i> (Schneider) | <i>Shevada</i> | Entire | All seasons |
| 39. | <i>Pseudotropius etherinoides</i> | <i>Vayadi</i> | Entire | All seasons |
| 40. | <i>Sylondia sykesii</i> (Sykes) | | Lentic | Rare |

Family : Bagridae

- | | | | | |
|-----|------------------------------------------|----------------|--------|-------------|
| 41. | <i>Mystus cavasius</i> (Ham.) | <i>Shengta</i> | Entire | All seasons |
| 42. | <i>M. (Aorichthys) seenghala</i> (Sykes) | <i>Singhi</i> | Entire | All seasons |

Family : Sisoridae

- | | | | | |
|-----|-----------------------------|------------------|--------|--------|
| 43. | <i>Gagata itchkea</i> (Day) | <i>Itchakiya</i> | Lentic | Summer |
|-----|-----------------------------|------------------|--------|--------|

Order : Beloniformes**Family : Belonidae**

- | | | | | |
|-----|-----------------------------------|--------------|--------|--------|
| 44. | <i>Xenentodon cancilla</i> (Ham.) | <i>Kutra</i> | Lentic | Summer |
|-----|-----------------------------------|--------------|--------|--------|

Order : Mugiliformes**Family : Mugilidae**

- | | | | | |
|-----|----------------------------------|----------------|--------|-----------------|
| 45. | <i>Rhinomugil corsula</i> (Ham.) | <i>Vardola</i> | Lentic | Summer & Winter |
|-----|----------------------------------|----------------|--------|-----------------|

Order : Channiformes**Family : Channidae**

- | | | | | |
|-----|-------------------------------|---------------|--------|------|
| 46. | <i>Channa gachua</i> (Ham.) | <i>Murrel</i> | Lentic | -do- |
| 47. | <i>Channa marulius</i> (Ham.) | <i>Murrel</i> | Lentic | -do- |

Order : Symbranchiformes**Family : Gobidae**

- | | | | | |
|-----|-----------------------------------|----------------|--------|-------------|
| 48. | <i>Glossogobius giuris giuris</i> | <i>Kharpya</i> | Entire | All seasons |
|-----|-----------------------------------|----------------|--------|-------------|
-

Table XIII : Species-wise fish landings from Bhatghar Reservoir (in kg)

| Year | C. catla | L. rohita | C. mrigala | T. Khudree | P. dobsonii | W. attu | P. kolus | C. fulungee | Chela sp. | Eels | Murrels | Mugil | Misc. | Total |
|----------------|----------------|--------------|----------------|----------------|----------------|----------------|-----------------|-----------------|----------------|---------------|---------------|--------------|----------------|-----------------|
| 1987 | 140.00 | 9.00 | 374.25 | 361.25 | 143.50 | 368.25 | 9574.00 | 10726.00 | 2930.00 | 41.0 | 17.25 | 7.25 | 15.00 | 24706.75 |
| 1988 | 43.00 | 17.00 | 727.00 | 85.00 | 427.00 | 1126.00 | 4667.00 | 5576.00 | - | 140.01 | 39.50 | 10.00 | 4.00 | 12721.50 |
| 1989 | 25.87 | - | 155.04 | 1023.95 | 441.15 | 1439.81 | 1750.69 | 4254.47 | - | - | - | - | 47.89 | 9278.87 |
| 1990 | 441.00 | - | 183.75 | 16.00 | - | 194.50 | 1019.00 | 1729.00 | 3095.00 | 59.00 | 120.80 | - | 2200.00 | 8999.05 |
| 1991 | 420.00 | - | 285.00 | 88.00 | - | 317.50 | 2278.00 | 2386.05 | 3383.00 | - | 485.00 | - | 2398.00 | 12099.55 |
| Total | 1069.87 | 26.00 | 1725.04 | 1574.20 | 1011.65 | 3446.06 | 19288.69 | 24671.52 | 9408.00 | 240.00 | 662.55 | 17.25 | 4664.89 | 67809.72 |
| Average | 213.98 | 5.20 | 345.01 | 314.84 | 202.33 | 689.21 | 3857.74 | 4934.30 | 1841.60 | 48.0 | 132.50 | 3.45 | 932.98 | 13521.14 |
| % | 1.58 | 0.04 | 2.54 | 2.32 | 1.49 | 5.08 | 28.45 | 36.39 | 13.87 | 0.35 | 0.98 | 0.03 | 6.88 | 100.00 |