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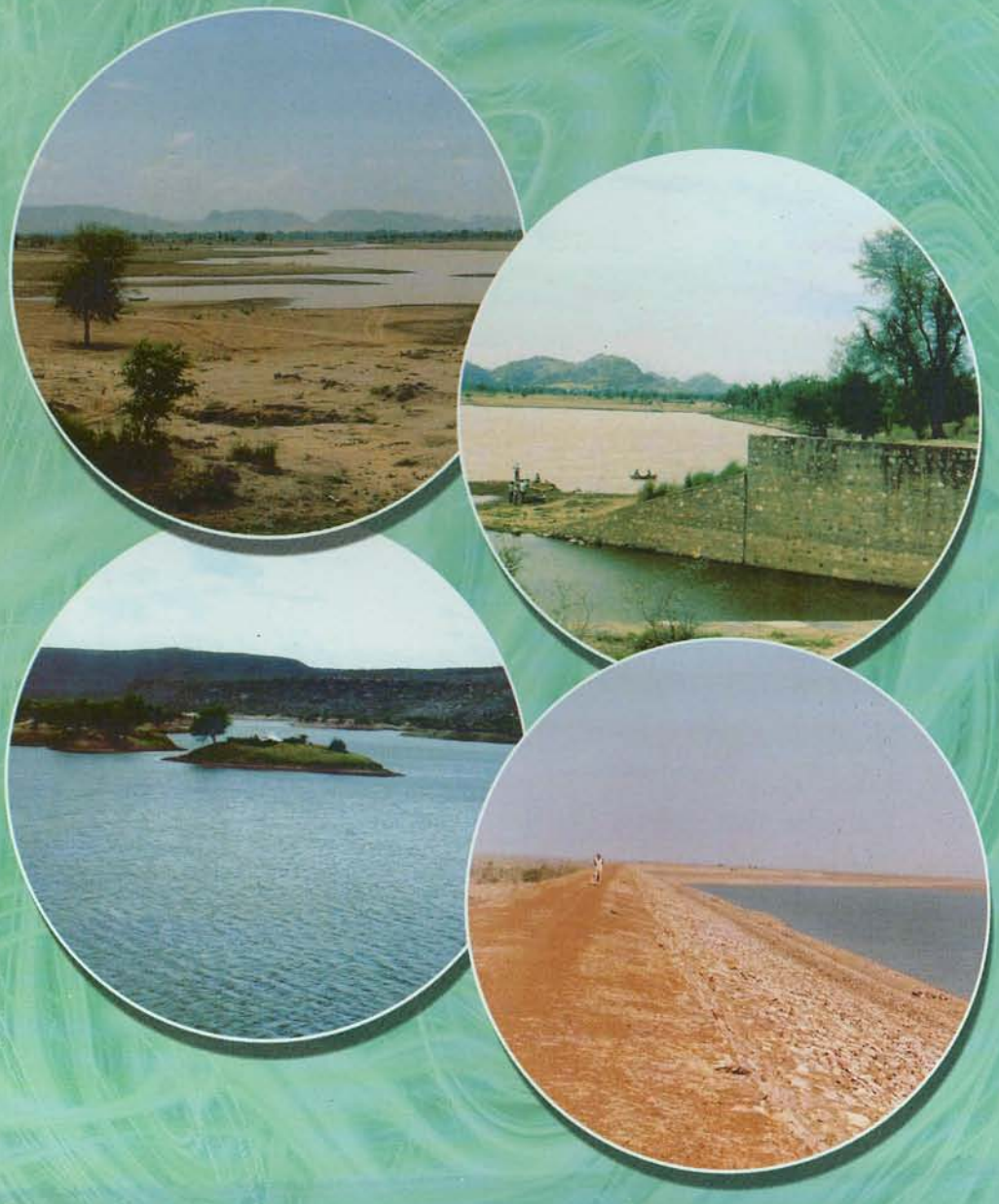
2007

ECOLOGY BASED FISHERIES MANAGEMENT IN SELECTED SMALL RESERVOIRS OF RAJASTHAN



CENTRAL INLAND FISHERIES RESEARCH INSTITUTE

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ECOLOGY BASED FISHERIES MANAGEMENT IN SELECTED SMALL RESERVOIRS OF RAJASTHAN

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FOREWORD

The development of reservoir fisheries has greater relevance in the fast developing countries like India. The resources have special role to play in the development of the country's Inland Fish production. Even a modest hike or increase in the yield rate from these resources can add substantially to the inland fish production. Management of reservoir fishery has assumed enormous importance in the inland open water sector in view of the urgent need to augment the country's inland fish production. Development of reservoir fisheries has tremendous scope for yield enhancement besides being more labour incentive and eco-friendly in nature. Small reservoir fishery development is significant as water bodies can be easily managed and have got the potential of highest productivity by simple stock enhancement and judicious management.

As a part of studies, qualitative and quantitative assessment of limno-chemical and biotic variables were assessed in. respect of selected small reservoirs of Rajasthan from April 2002 to March 2006.This publication is the documentation of the research data generated during the investigation. I am hopeful that the document will be of great help in formulating guide lines for the scientific management not only of the reservoirs investigated but also of other similar water bodies available in the region.

I place on record the valuable co-operation received from various field staff of Rajasthan fisheries Department, during the investigations. The unflinching support received from the Director and Joint Director of Rajasthan fisheries Department is thank fully acknowledged.

DIRECTOR

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(V. K. Sharma)

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INTRODUCTION

Consequent to harnessing of the rivers for irrigation and hydroelectric power generation during post independence era, a number of small, medium and large man made lakes have come up through out India. These man made lakes hold tremendous potential for inland fisheries development. However, this vital resource is not contributing as it should have been. Judicious management of these resources can lead to ever more production from these water bodies.

The state of Rajasthan located in Western part of the country between latitude 23°-41' to 30°-11' N and longitude 69°-29' to 78°-16' shows a wide disparity in water resources, and agro-climatic conditions. Rajasthan state has got an area of 342239 Km^2. The state has got 3.3 lakh ha of water area under fish culture of which 1.2 lakh ha is contributed by large and medium reservoirs, while 1.8 lakh ha is in form of small reservoirs and ponds. Of the 423 reservoirs listed by Rajasthan fisheries deptt., only four are in large category, while 389 are small and 30 are medium size reservoirs. The large reservoirs viz. Rawatbhata (19600 ha) in Chittorgarh district ; Mahi Bajajsagar (13500 ha) in Banswara district ; Jaisamand (7600 ha) in Udaipur district and Kadana back waters (9000 ha) in Banswara and Dungerpur district form about 32% of total reservoir area of state. (map).

Management practices with proper stock manipulation and judicious stocking and exploitation are the key to achieve high productivity from the ecosystem.Taking a clue from this concept the exploratory survey of selected small reservoirs of Rajasthan was initiated in 2002-03.Ten reservoirs were selected for the purpose of present study. These are,Sawn Bhadon (Kota district), Mundliya kheri (Jhalawar district), Bundh Bilas (Baran district), Urmila sagar & Ram Sagar, (Dholpur district).Jaggar, Needar and Mamchari (Karoli district), Mansarovar and Harsora (Alwar district).

Study covering morphometric and hydrological characteristics, soil and water quality parameters, carbon production, abundance of fish food resources and fish catch statistics were made on seasonal survey basis during pre-monsoon (May to June), post monsoon (Oct to November) and winter (January to Feb.) in the year 2002 -03 in respect of Sawan Bhadon, Mundilya Kheri and Bundh Bilas, 2003-04 in respect of Urmila Sagar and Jagger, Ramsagar, Needar and Mamchari in 2004-05 and in respect of Mansarovar and Harsora reservoirs in 2005-06..

SAMPLING PROCEDURE

Sampling pertaining to limnological parameters were collected once in the season from the reservoirs.The physico- chemical parameters of water were determined following the standard methods given in APHA (1989).The collection and analysis of biological parameters were done as desgribed by Jhingran et al.,(1969).

1. Sawan Bhadon reservoir:- (Fig. 1-2)

1.1 Morphometric and hydrological characteristics:-

The morphometric and hydrological parameters of the reservoirs are presented in table1. Sawan Bhadon reservoirs is situated at latitude 24°-50'N and longitude 76° 07',in Kota districts on river Aru and come up in 1991-92. The reservoir has an average area 412.5 ha with mean depth of 7.3 m and catchment area of 146 km^2. The low mean depth of 7.3 m indicate shallow character of the reservoir. The ratio of catchment area/ area of reservoir (considered to be an index of allochthonous inputs) is 35.4 indicates input of nutrients through catchment area.

Fig. 1 A vew of Sawan Bhadon Reservoirs

Fig. 2 Another vew of Sawan Bhadon Reservoirs

33.6% in Sawan Bhadon, *Microcysts* was dominant constituent of blue green algae. Dinophyceae was abundant (19.7%) in Sawan Bhadon and was mainly represented by *peridinium*. This was dominant in winter. *Synedra, Navicula,Tabellaria, Gyrosigma* and *Diatoma* were the common diatoms occurred in the reservoir.

Copepods (*Cyclops, Diaptomus, naupulii*) and cladocera (*Daphnia, Moina Bosmina*) formed bulk of zoo plankton. *Brachionus, Keratella, Filinia, Trichocorca,* was the common form of rotifers occurring. Occurrence of *Oscillatoria; Mircocystis* and *Pediastrum* indicated eutrophic tendency of the water body.(Fig.3).

b) **Periphyton -** The mean periphytic population varied from 1705 (Post-monsoon) 2635u/cm^2 (winter) with mean being 2170u/cm2. Chlorophyceae formed 14.7% Myxophyceae13.6% and protozoons 2.3%. The dominant group is Bacillariophyceae being 69.4%. Protozons appeared only in pre- monsoon season. Maximum density of periphytic organisms was in winter season (table 6). *Synedra, Tabellaria, Diatoma Meridion, Gomphonema, Fragellaria Novicula, Gyrosigma, Cymbella, Frustulia & Coloncis* were the cammon diatoms observed.(Fig 4).

c) **Macrobenthos -** The standing crop (no/m^2) of macrobenthos was maximum in post monsoon (900)and minimum in winter (500). The averge standing being 700 no/m^{2}with mass being 6.90g/m^2. Chironomids formed 61.85% where as Chaoborus larvae and mosquito leave formed 14.28% each in total benthos (Table 7).

d) **Macrovegetation -** There is no macrophytes noticed in all the three sampling from Sawan Bhodon due to the rocky strata all around the reservoir (Table 3).

1.4 Catch statistics:-

The fish from the reservoir is being exploited through an open anction system for a period of 3 years. The fishing is done by the specialized fishermen parties hired by the contractor from time to time.The lease amount for the year 2002 2003 was Rs. 95625.Stocking is done by the contractor.Available records show that an average stocking of 3440 fries ha-1 was done in Sawan Bhadon (Table 11) during the period 1998 -99 to 2002-2003.

The fish yield (kg ha^{-1}) in the year 2001 -02 was 199kg /ha from this reservoir where as during April 02 Jan -03 it was 29.17t or 118kg/ha. Composition wise Indian major carps formed 32.74%, minor carps dominated with 45.94% followed by misc. fishes 21.32%. No catfish were recorded during period April 2002 -03 where as 4.63t cat fish was recorded in 2001-02 (Table 9 and Table 10).

The species composition has revealed that Indian major carps accounted fairly good proportion in the catches which could be due to the impact of stocking..*C.Catla, L.rohita, and W.attu C.mrigala, L.calbasu, M.seengala, L.gonius* have been observed from the reservoir.

1.5 Productivity Status:-

The potential of fish production kgha-1 on basis of carbon assimilation has been estimated at 300kg for Sawan Bhadon against the present 118kg/ha. A sound management programme based on the yield potential and availability of fish food resources is therefore needed.In Sawan Bhadon 550 fingerlings/ha be stocked in the ratio of catla 4: rohu 3: and mrigala 3. Fish production can be further enhanced significantly by adopting

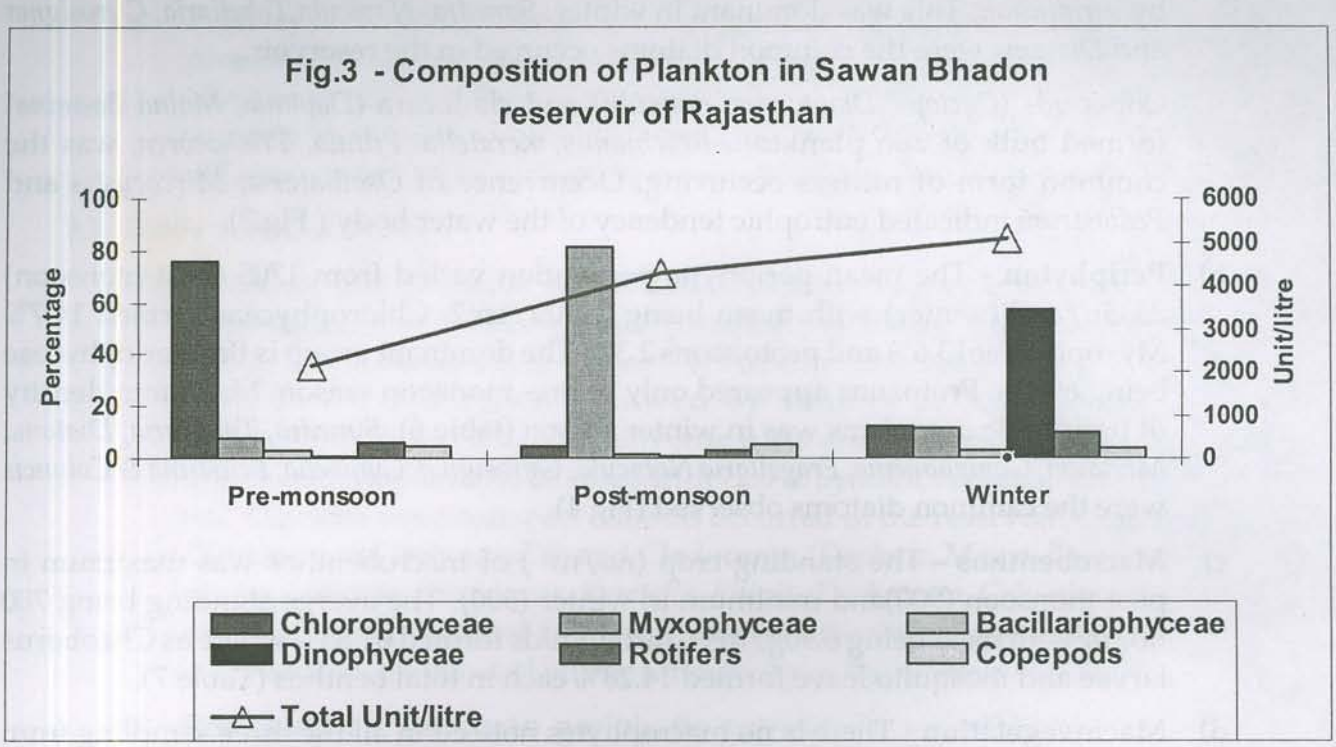
Fig.3 - Composition of Plankton in Sawan Bhadon reservoir of Rajasthan
Percentage
Unit/litre
100
80
60
40
20
0
6000
5000
4000
3000
2000
1000
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Dinophyceae
Myxophyceae
Rotifers
Bacillariophyceae
Copepods
Total Unit/litre

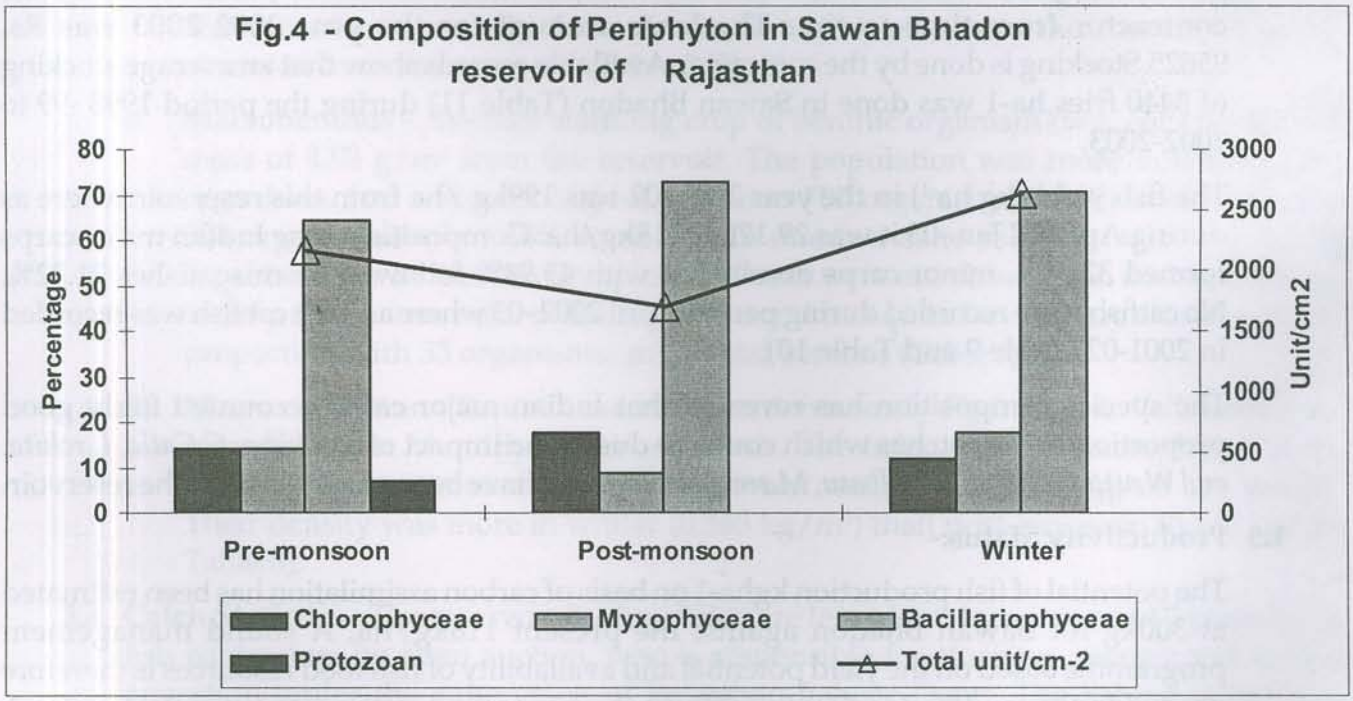
Fig.4 - Composition of Periphyton in Sawan Bhadon reservoir of Rajasthan
Percentage
Unit/cm2
80
70
60
50
40
30
20
10
0
3000
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Protozoan
Myxophyceae
Total unit/cm-2
Bacillariophyceae

judicious exploitation policy.Gill nets of mesh bar 40-60 mm may be used regularly instead of their seasonal use. Removal of tree trunks would prove beneficial for operating gill nets without hindrance.

2. Mundliya Kheri Reservoir :- (Fig 5-6).

2.1 Morphometric and hydrological characteristics:-

The morphometric and hydrological parameters of the reservoir are presented in table 1. Mundliya kheri reservoir is situated near Jhalarapattan in Jhalawar district at latitude 24° 32'N and longitude 76° 10'E in the district of Jhalawar on river Chandra Bhaga. Its construction dates back to state times and is primarily ment for drinking water purpose for near by Jhalarapattan and Jhalawar towns in addition to flood control and irrigation purposes. The reservoir has an average area of 750 ha with catchment area 52.4 km^2 and C/A ratio being 7.0.It is very shallow reservoir mean depth being only 0.6m and average rainfall in the area being 510.8 mm.

2.2 Limnology and productivity:-

a) **Soil Quality -** Observation on the physico chemical characteristics of the basin soil are presented in table 2. Soil is clay and alkaline with pH being 7.5. Organic carbon 0.75% and free calcium carbonate 1.63%, available phosphorus 2.4 mg /100gms and available nitrogen 8.54mg/100gm were of moderate range. The nutrient status of soil thus reflected productive nature of soil.

b) **Water Quality -** Water quality in terms of physical and chemical feature is presented in Table 3. The mean surface temp. was 26.0 °C with overall range of 19.0 °C in winter and 30.0 °C in post monsoon.The wide variation in water temperature thus had a great bearing on the heat cycle of the reservoir. The mean transparency was 75 cm (range 15-122 cm). High turbidity during pre-monsoon period could be attributed to the shallowness of the reservoir coupled with turbulence due to high wind action.

Alkaline nature of water is evident from pH range 7.6-8.5 (mean 8.2), DO was in congenial range of 7.6 -9.6 mgl^{-1} (mean 8.9 mgl^{-1}).Value of DO was low in pre-monsoon and high in post monsoon, total alkalinity was above 90 mgl^{-1} (range 90-112 mgl^{-1}) which indicates the productive character of water. Higher values of alkalinity during pre-monsoon and lower in winter could be due to reduced water levels in pre-monsoon and winter rains in winter respectively. Specific conductivity of water ranged between 150.0-412.0µmhos/cm (mean 262.0µmhos/cm) supported the productive character of the reservoir.

Calcium concentration was moderate (19-26mgl^{-1}), magnesium contents varied between 8.6 -15.6 mgl^{-1}(mean 11.1 mgl^{-1}), Total hardness is reflected by trends of magnesium. Chloride ranged between 26.0-43.0mgl^{-1} (mean33.0 mgl^{-1}).The concentration of phosphate varied from 0.20-030mgl^{-1}, silicate 0.41-1.60mgl^{-1} (mean 0.88 mgl^{-1}) was favorable The rich water quality reflect the transport of allochthonous dissolved nutrients and their leaching into the system.

In Mundliya kheri reservoir the depth-wise observations in respect of temperature (table 3.2) did not show any thermal stratification as temperature from surface to bottom (3 m.) remained unchanged. Chemical stratification for the parameters like

dissolved oxygen, total alkalinity and specific conductivity showed a weak chemical stratification.

c) **Primary production -** The data on average primary production from the reservoir is presented in table 4.The gross production mgC/m^3 /day)was 88.764 for mundliya kheri reservoir and the net production being 500.04.The post monsoon season in variably exhibited low rate of production due to dilution of ions. The assimilation efficiency was 56.33% exhibiting productive character of the reservoir.

2.3 Biotic communities:-

a) **Plankton -** Observation on the planktonic abundance and their composition is presented in table 5. The density of plankton population was lowest in post monsoon (916 u/l) and maximum in winter (7479 u/l) average being 4611 u/l. Chlorophyceae with 54.4% dominated fallowed by rotifers 20.2% Myxophyceae 10.4% Bacillariophyceae 7.8%, Dinophyceae 0.5% and Copepods 6.7%. Phytoplankton dominated the plankton biomass with 72.0%. *Synedra, Navicula, Tabellaria, Gyrosigma* and Diatoma were common diatoms occurred in the reservoir. Copepods (*Cyclops, Diaptomus and their naupllii*) and Cladoceran (*Daphnia, Moina, Bosmina*) formed bulk of zooplankton. *Brachionus, Keratella, Filinia, Trichocerca, Colurella* was the common forms of rotifers noticed from this reservoir. Occurrence of *Oscillatoria, Microcystis* and *Pediastrum* indicated eutropic tendency of the water. (Fig. 7)

b) **Periphyton -** The mean periphytic population varied from 1395 u/cm^2 (post monsoon) to 2325 u/cm^2 (winter season). Average population of periphyton observed from Mundliya Kheri reservoir is 1860 u/cm^2. Chlorophyceae were only 10.9% of total periphyton. Bascillariophyceae with 69.5% dominated with myxophyceae (17.4%) following it. Protozoons formed 2.2 % which appeared only in pre monsoon season (Table,6). *Synedra, Tabellaria, Diatoma, Meridion, Gomphonema, Fragellaria, Navicula, Gyrosigma, Cymbella, Frustullia & Coloneis*, were the common diatoms observed from the reservoir (Table 7,Fig.8)..

c) **Macrobenthos -** Average standing crop of benthic organism (nos./m^2) is 750 with mass of 4.93 g/m^2 from the reservoir. The population was more in summer 800 organisms /m^2 and least in post monsoon 700 organisms/m^2. Chironomids with 300 organisms/m^2 or 40% were next in dominance to molluscs which were 350 organisms/m^2 or 46.67%. Complete molluscs were not observed in the bottom biota as only shells were recorded. Chaoborus and mosquito larvae were almost equal in proportion with 33 organisms/m^2 in total benthos (Table 7).

d) **Macrovegetation -** Aquatic macrovegetation namely *Hydrilla* and *Vallisneria* were recorded from Mundliya Kheri reservoir. The infestation of macrophytes in the reservoir was estimated at 0.455 kg/m^2 wet weight and 0.093 kg/m^2 dry weight. Their density was more in winter (0.565 kg/m^2) than post-monsoon (0.230 kg/m^2, Table 8).

2.4 Catch Statistics - The reservoir fishing rights are leased out for a period of 3 years to the fish contractors by open auction, who is responsible for stocking, rearing and fishing operation under the supervison of Rajasthan fishery Deptt. The fishing is done by specialized fishing parties hired for the purpose by the contractors. No regular fishing is done through out the year. The lease amount for Mundliya Kheri for the year 2002-03

Fig. 3 A vew of Mundliya Kheri Reservoir

Fig. 6 Another view of Mundliya Kheri Reservoir

was Rs 42522/-. Available records shows that an average stocking of 155 fries ha^{-1} was done in Mundliya Kheri during the period 1998-99 to 2002-03 (Table 11) During the period April 2002-Jan. 2003 (Table 10) a total of 13.59t of fish was caught. Indian major carps contributed 70% of total. The production of 8.0 kg/ha was recorded in 2001-02 (Table 9) with a total catch of 3.557t which was contributed by 1.584t IMC, 0.215t cat fish and 1.758t minor carps. This catch increased to 30 kg/ha in 2002-03 (Table 10) with IMC catch of 9.512t, catfish 2.039t, minor carps 1.359t and misc. fishes 0.680t. This could be due to the impact of stocking.*Catla catla, L.rohita, C. mrigala,L. calbasu,M. seenghala, L. gonius, W.attu* were the species observed in catches.

2.5 **Productivity status**:- the potential fish production kg ha-1 on basis of carbon assimilation has been estimated to be 220kg ha^{-1} against present production of 30 kg/ha. The impoundment falls under medium productivity category.The hydrological feature especially total alkalinity, electric conductance and concentration of calcium, magnesium and phosphate suggest the productive nature of the reservoir.

A sound management programme based on the yield potential and availability of fish food resources is there fore needed.Mundliya Kheri needs stocking @400 fingerlings ha^{-1} with emphasis on Catla, Rohu, and Mrigal in 50mmsize to realize the potential of 220kg (ha^{-1}. Fish production can be further enhanced significantly by adopting judicious exploitation policy

3. **Bund Bilas :- (Fig.9-10)**

3.1 **Morpho metric and hydrological characteristics -** The morphometric and hydrological parameters of the reservoir are presented in table 1. Bundh Bilas is situated at latitude 25°20'N and longitude 76°49'E in Baran district of Rajasthan and was constructed in the year 1996. The reservoir is meant primarily for flood control and irrigation purpose and has area at FRL 610.0 ha with catchment of 233.0 km^2. The C/A ratio 38.2 indicates input of nutrients through catchment area. The reservoir is shallow with mean depth of 4.7m. The average rain-fall during the year being 291.0 mm. The reservoir came up over river Bilas.

3.2 **Limnology and productivity:-**

a) **Soil Quality -** Observation on the physico-chemical characteristics of basin soil is presented in table 2.The soil of bundh Bilas is alkaline with pH being 7.12. Organic carbon is 0.52%.Available phosphorus is 1.7mg/100gm and available nitrogen is 6.68 mg/100g which is in moderate range. Electric conductance is 224.0µmhos/cm. The status of soil nutrients thus reflected productive nature of soil.

b) **Water Quality -** The findings of water quality of the reservoir presented in the table 3.The mean surface temperature of water was 22.2C° with range of 21.5C°in winter and 31.°C in post monsoon.The vide variation of water temperature has great bearing on the heat cycle of the reservoir.The average transparency observed was 62 cm (range 57-69cm).

Alkaline nature of water is evident from its pH being 8.0 (range 7.8-8.2).The dissolved oxygen is 9.0 $mg1^{-1}$ (range 8.4-9.4 $mg1^{-1}$) It was low in pre-monsoon and high in post monsoon.The mean total alkalinity is 111.0$mg1^{-1}$. Specific conductivity was 167µmhos/cm. Higher values of alkalinity in pre monsoon is due to the reduced water level and more concentration of ions. Lower values in winter could be due to

Fig. 7 - Composition of Plankton in Mundliya Kheri reservoir of Rajasthan

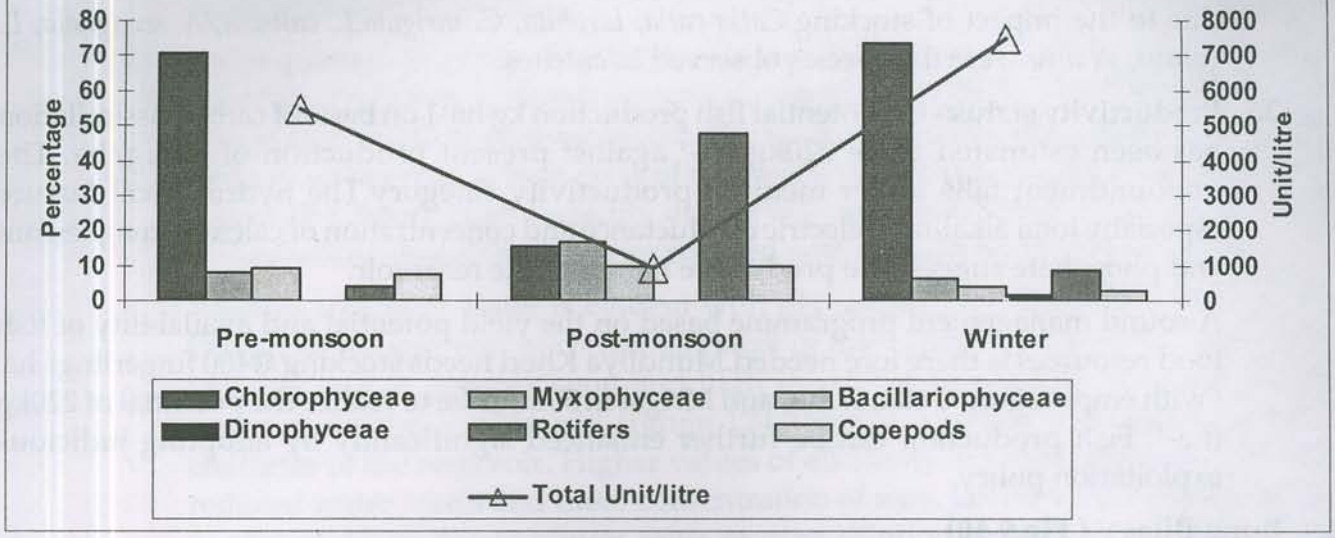

Fig.8 - Composition of Periphyton in Mundliya Kheri reservoir of Rajasthan

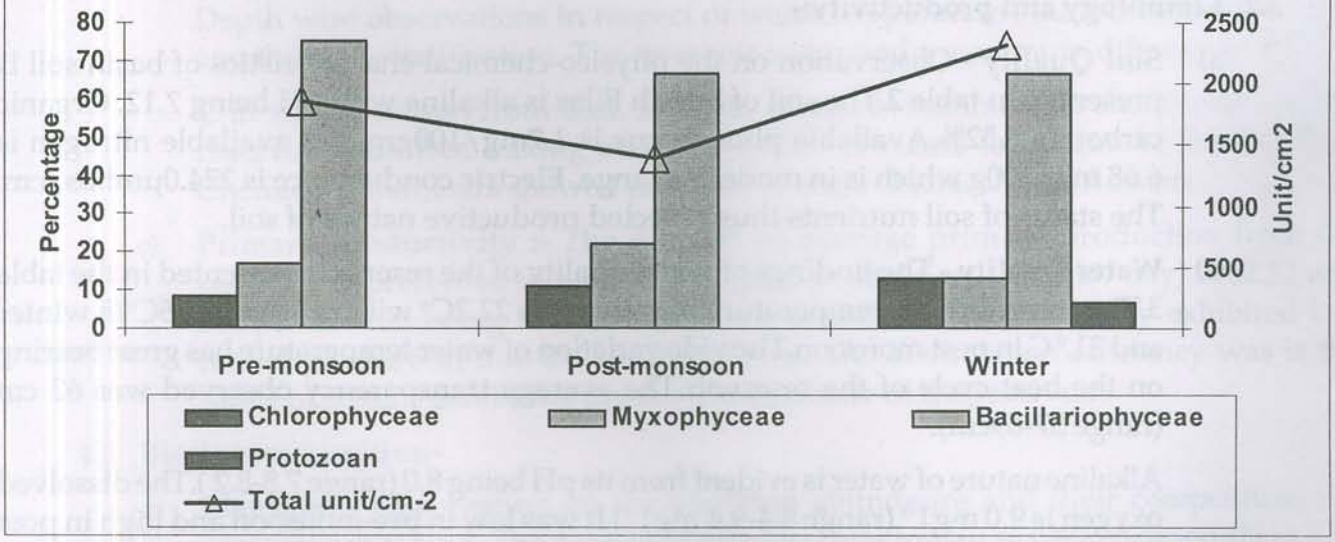

Fig. 9 A veiw of Bund Bilas Reservoir

Fig. 10 Another veiw of Bund Bilas Reservoir

winter rains. The ionic concentration supported the productive character of the reservoir.

Calcium concentration was moderate 22.3mgl^{-1}(range18.0-30.0mgl^{-1}), Magnesium was 12.9mgl^{-1} (10.2-16.8), available phosphate 0.28mgl^{-1} (range 0.22-0.32) and silicate 0.65mg1-1(range 0.50-0.85 mgl^{-1}).Chloride was 9.50mg1-^{1}(range 8.5-11.0 mgl^{-1}). The rich water quality reflects the allochthonous dissolved nutrients leaching into the ecosystem.

In Bund Bilas (table 3.3) depth wise observations in respect of temperature did not show presence of thermal stratification. The reservoir water had a maximum difference of 1 ^{0} C in post monsoon season from 4 to 6 m. depth. The chemical parameters sowed presence of a weak chemical stratification.

c) **Primary productivity -** The findings on the estimation of primary production of Bundh Bilas are presented in Table 4. The gross production (mgC/m^3/day) was estimated as 958.32 and net production 483.36. The post monsoon season invariably exhibited low rate of production due to dilution of ions. The assimilation efficiency was 50.44%, exhibiting productive character of reservoir.

3.3 Biotic communities:-

a) **Plankton -** Observations on the plankton abundance and composition is presented in Table 5. The density of plankton was lowest in post monsoon (419 u/l), whereas it was highest in pre-monsoon (2341 u/l). Average plankton population was 1398 u/l. Chlorophyceae formed maximum with 25.1%, followed by Myxophyceae 22.6%, Bacillariophyceae 19.5% and rotifers being 16.5%. Dinophyceae formed only 5.2%. Copepods were 11.1% in the reservoir. Microcystis was dominant constituent of blue green algae and was of significance in post monsoon period. Dinophyceae was mainly represented by *Peridinium. Synedra, Navicula, Tabellaria, Gyrosigma* and *Diatoma* were common diatoms occurred in this reservoir.

Copepods (*Cyclops, Diaptomus*) and cladocerous (*Daphnia, Moina, Bosmina*) formed bulk of zooplankton. The common rotifers noticed belong to *Brachionus, Keratella, Filinia* and *Trichocerca.(Fig. 11).*

b) **Periphyton -** The mean periphytic population from Bundh Bilas was 2221 u/cm^2 with least in post monsoon (1860 u/cm^2) and maximum in winter(2480 u/cm^2) Bacillariophyceae dominated periphytic communities 70.2% of total followed by Chlorophyceae (15.7%) & Myxophyceae (12.0%).. *Synedra, Tabellaria, Diatoma, Meridion, Gomphonema, Fragilaria, Navicula, Gyrosigma, Cymbella, Frustulia, Caloneis* and *Diatoma* were common forms of diatoms.

c) **Macrobenthos -** Benthic population in Bundh Bilas (Table 7) were maximum in winter (1000 org/m^2) and least in post monsoon (100 org/m^2). Average population was 567 org/m^2 with 5.88 gm/m^2. Diptera larvae (Chaoborus and Chironomids) and mollusks constituted bulk of bottom biota. Tubificid formed 14.6% of total benthos in Bundh Bilas. Chironomids formed 52.91 % and Chaoborus constituted 11.82%.

d) **Macrovegetation -** No aquatic weeds have been observed in Bundh Bilas due to vide fluctuation in water levels (Table 8).

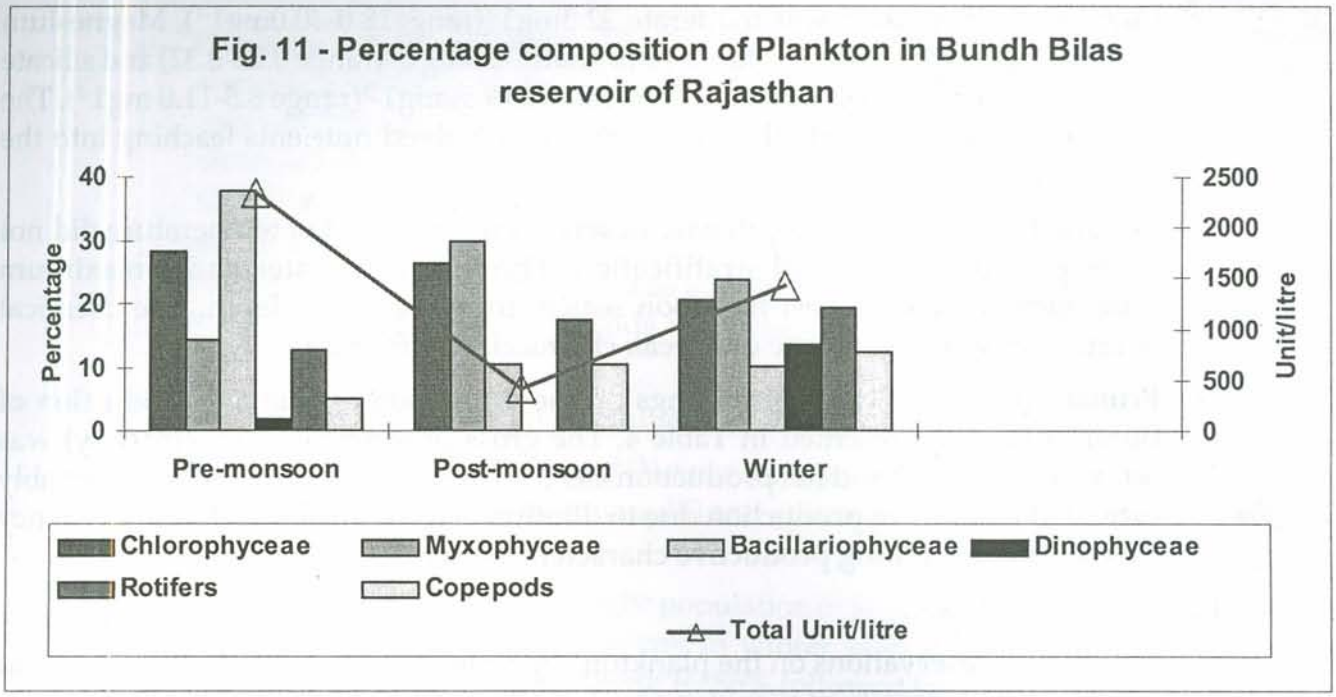
Fig. 11 - Percentage composition of Plankton in Bundh Bilas reservoir of Rajasthan
Percentage
Unit/litre
40
30
20
10
0
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Myxophyceae
Bacillariophyceae
Dinophyceae
Rotifers
Copepods
Total Unit/litre

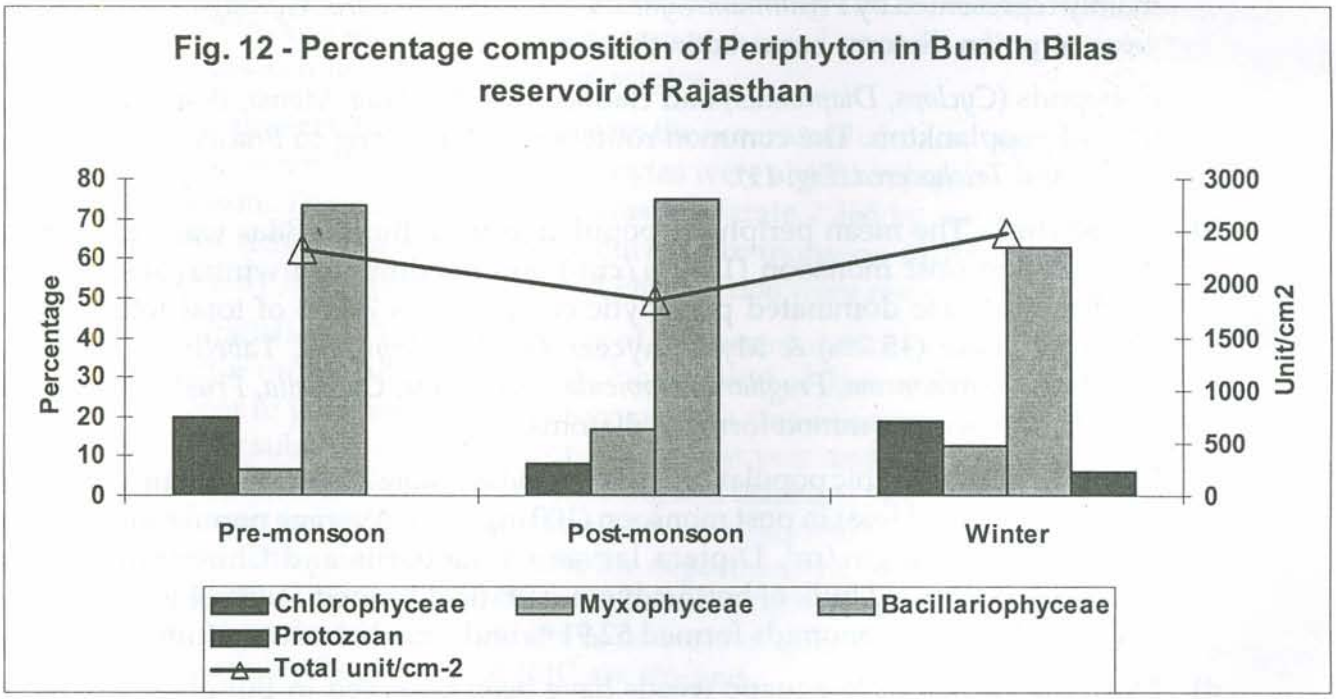
Fig. 12 - Percentage composition of Periphyton in Bundh Bilas reservoir of Rajasthan
Percentage
Unit/cm2
80
70
60
50
40
30
20
10
0
3000
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Myxophyceae
Bacillariophyceae
Protozoan
Total unit/cm-2

Fig. 13 A view of Urmila Sagar Reservoir

Fig. 14 Another view of Urmila Sagar Reservoir

3.4 **Catch Statistics -** Unlike other reservoirs of Rajasthan, Bundh Bilas has been taken up by ASSEFA a non Govt. organization which is engaged in social welfare projects for the upliftment of villagers of the area. Bundh Bilas has been leased out to ASSEFA for Rs 82,800/- for year 2002-03. The fishing is being done by the fishermen community of nearby villages. Stocking of Bundh Bilas was done to the tune of 10 lakh in 1988-89, 4.67 lakh in 1999-2000, 0.49 lakh in 2000-01, 15.0 lakh in 2001-02 and 3.75 lakh in 2002-03 (Table 11).

The fish yield (Kg ha^{-1}) during the year 2001-02 was 81.0 kg. Indian major carps contributed 56.8% (Table 9). Cat fish with 2.477 t formed 8.36%. Misc. being 17.91% and minor carp contributed 17.03%.

During 2003-03 fish production from the reservoir was 82.0 kg ha^{-1} with IMC forming 53.24%, cat fish 5.92%, minor carps 16.52% and misc. being 24.32%. A total of 30.173t fish was caught during 2002-03 (Table 10). The species composition has revealed that Indian major carps accounted fairly good proportion of catches, which could be due to impact of stocking other fishes observed were *P. sarana, M. armatus, W.attu* and *Chann sp.*

3.5 **Productivity status -** The potential fish production kg ha^{-1} on the basis of carbon assimilation has been estimated as 230 kg for Bundh Bilas against the present production of 81.0-82.0 kg. The hydrological features especially total alkalinity, electric conductance and concentration of calcium, magnesium and phosphate suggest the productive nature of the reservoir.

Fishing is done by fishermen belonging to ASSEFA. Bundh Bilas needs stocking of fingerlings in the ratio of Catla4: Rohu3: Mrigal3 @ 450nos/ha. Gill nets of mesh bar 40-60 mm may be regularly used instead of seasonal fishing. Removal of tree trunks would prove beneficial for operation of gill nets.

2. **Urmila Sagar Reservoir:- (Fig.13-14)**

4.1 Morphometric and hydrological characteristics:-

The morphometric and hydrological parameters of the Urmila Sagar reservoir more commonly known as Nibbi Dam are presented in table 1.The reservoir is located at latitude 26°46'N and longitude 77°45'E in the Dholpur district of Rajasthan on river Babudhen of Parvati river basin of Chambal valley. The reservoir which is primarily meant for flood control was constructed in 1905 and has area of 500 ha at FRL. The catchment of the reservoir has an average area of 77.7 km^2 and C/A ratio being 15.54 which input of nutrients through catchment area. The average annual rainfall in the area is 640mm.

4.2 Limnology and productivity:-

a) **Soil Quality** :- Observation on the physico-chemical characteristics of basin soil is presented in table 2. Soil of Urmila Sagar reservoir is loamy and alkaline with pH being 7.5. Organic carbon was 0.35% and the calcium carbonate 23.51%. Available phosphorus was 2.6mg/100gm and available nitrogen was 9.35 mg/100g. Electric conductance was 247.0µmhos/cm. The nutrient status of basin soil reflected productive nature of soil.

b) **Water Quality -** The findings of water quality of the reservoir presented in the table 3. The mean surface temperature of water was 25.34°C with range of 18.0-31.05°C.The vide variation of water temperature has great bearing on the heat cycle of the

reservoir. The average transparency observed was 66.67 cm (range 30—125cm). High turbidity during pre-monsoon period could be due to shallowness of reservoir coupled with wind action.

Alkaline nature of water is evident from its pH being 7.67 (range 7.4-7.9).The dissolved oxygen content 9.54 $mg1^{-1}$ (range 8.8-10.0 $mg1^{-1}$). The total alkalinity was 104.0-144.0 $mg1^{-1}$ (mean 121.0 mgl^{-1}). The mean Specific conductivity was 294.0µmhos/cm (range 256.0-356.0µmhos/cm). Higher values of alkalinity in pre monsoon is due to the reduced water level and more concentration of ions. Lower values in winter could be due to winter rains causing dilution of ions.

Calcium concentration was moderate 20.6-24.6 $mg1^{-1}$(mean 22.7$mg1^{-1}$), magnesium was 16.10 $mg1^{-1}$ (range 14.8-16.8 $mg1^{-1}$) which were moderate. Total hardness is reflected by the trends of magnesium. Chloride contents ranged between 8.0-9.0 $mg1^{-1}$ (mean 8.34$mg1^{-1}$).Phosphate contents ranged between 0.08-0.12$mg1^{-1}$ (mean 0.10 $mg1^{-1}$).The rich water quality reflects the transport of allochthonous dissolved nutrients and their leaching in to the system.

In Urmila sagar reservoir (table 3.4) the depth wise observations did not show presence of any thermocline as there is no change in water temperature from surface to 6 m. depth. A weak chemical stratification has been observed in respect of chemical parameters.

c) **Primary productivity -** The findings on the estimation of primary production of Urmila Sagar reservoir are presented in Table 4. The gross production (mgC/m^3/day) was estimated as 1042.44 while net production was 645.6. The assimilation efficiency was 61.93% which exhibited the productive nature of the reservoir.

4.3 Biotic communities:-

a) **Plankton** : The observation on the planktonic biomass and its composition is presented in table 5.The mean density of plankton was 2493u/l in Urmila Sagar with phyto plankton forming 76.08%. Myxophyceae occurred significantly with 20.65% *Microcistis* was dominant constituent of blue green algae. Post monsoon period showed myxophyceae to the extent of 42.16%. Bacillariophyceae was the dominant constituent with 35.98%.It was 66.5% in pre-monsoon period and 26.98% in winter.Dinophyceae was not observed in pre and post monsoon period, its mean population being 5.82%. Rotifers and copipods formed on an average of 10.35% and 13.58% respectively, (Fig.15).

Synedera, Navicula, Tabellaria and Diatoma were commam diatoms observed.Copepods (*Cyclops, Diaptomus* and their nauplii) and cladoceraus (*Daphnia*) formed the bulk of zooplankton. *Brachionus, karatella, Filinia, Trichocerca* were the common rotifers noticed in reservoir. Occurrence of *Oscillatoria, Microcystis, Pediastrum* indicate entrophic tendency of this water body.

b) **Periphyton -** The mean periphytic population from Urmila Sagar reservoir was (table 6) 3739u/cm^2 with Bacillariophyceae dominating with 40.85% followed by Chlorophyceae (39.84%) and myxophyceae 19.30%. Protozoans were not observed in the reservoir. Season wise winter months showed more periphyton with 5175 u/cm^2 as compared to pre monsoon 2557 u/cm^2.(Fig.16).

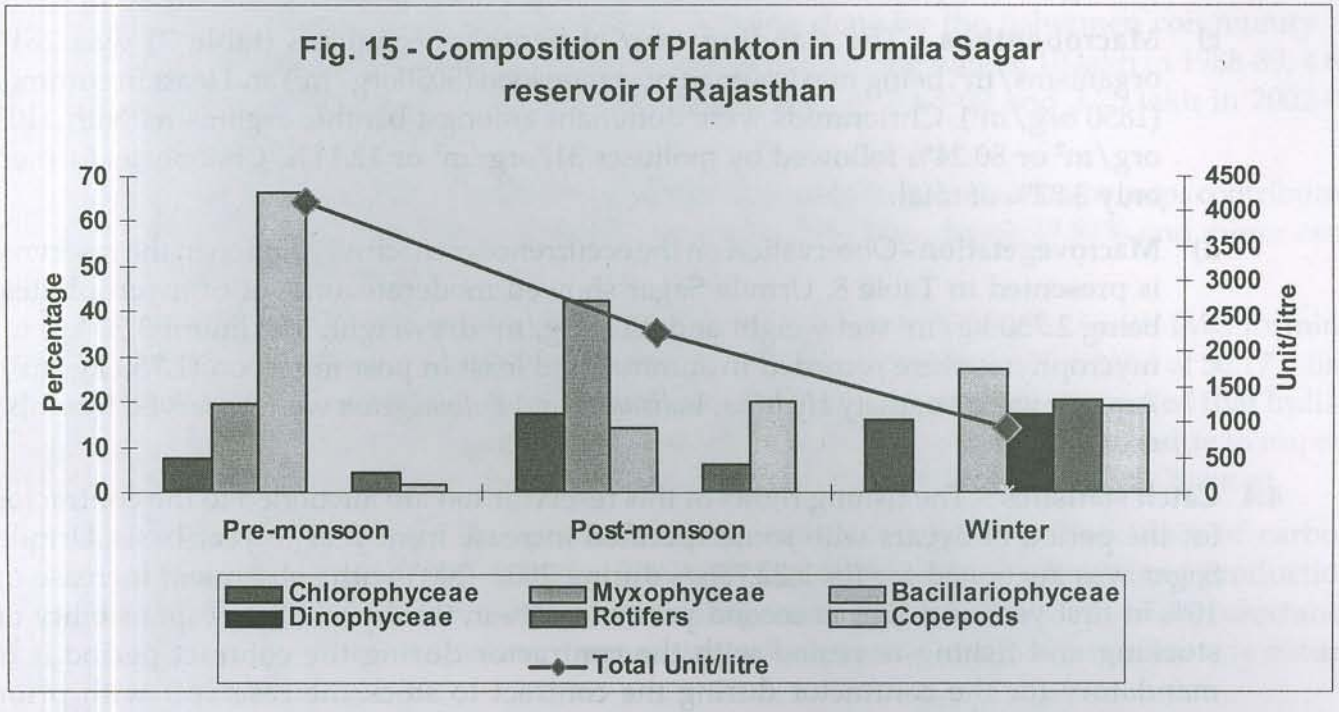
Fig. 15 - Composition of Plankton in Urmila Sagar reservoir of Rajasthan
Percentage
Unit/litre
70
60
50
40
30
20
10
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Myxophyceae
Bacillariophyceae
Dinophyceae
Rotifers
Copepods
Total Unit/litre

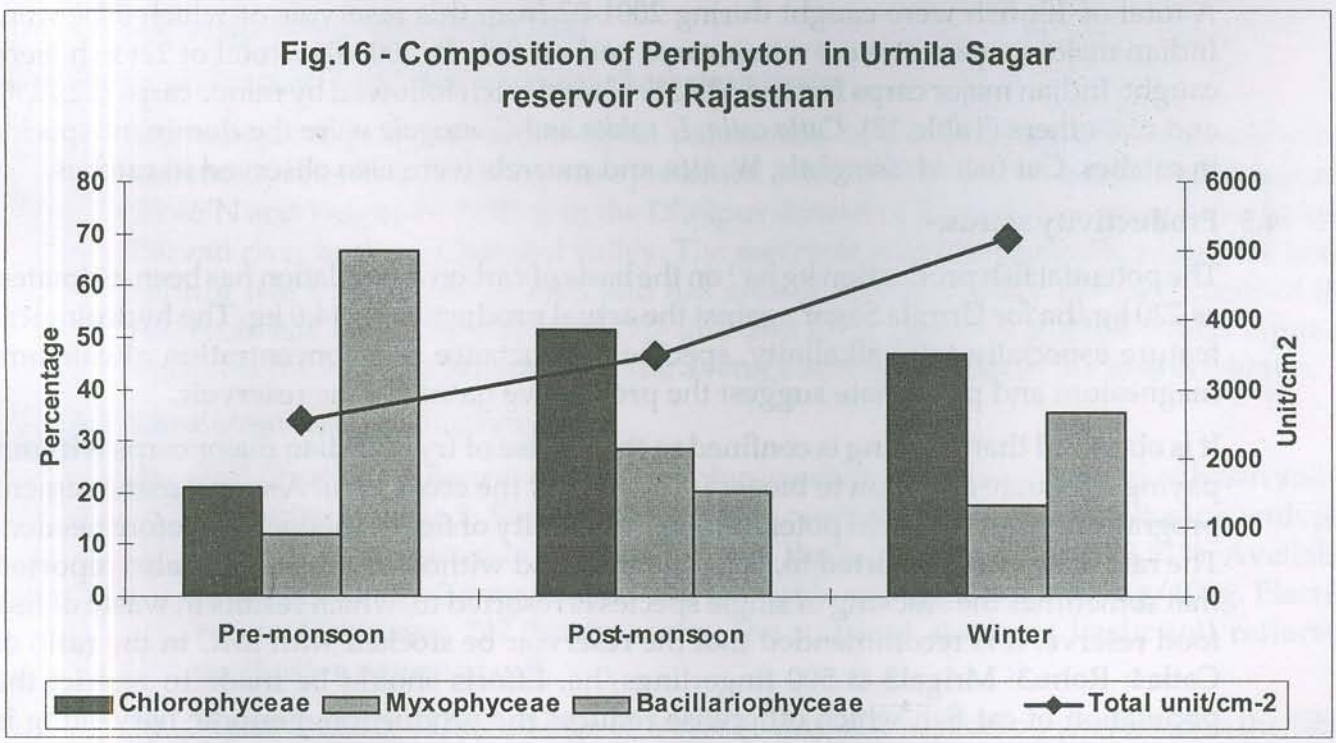
Fig.16 - Composition of Periphyton in Urmila Sagar reservoir of Rajasthan
Percentage
Unit/cm2
80
70
60
50
40
30
20
10
0
6000
5000
4000
3000
2000
1000
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Myxophyceae
Bacillariophyceae
Total unit/cm-2

Navicula, Cymbella, Fragillaria, Nitzschia Synedra Gomphonema, Chladophora, Cosmarium, Oedogonium, Synedesmus, Anoebena, Merishiopedia, Meridion, Spirulina were dominant among the periphytic the communities.

c) **Macrobenthos -** The standing crop of benthic organisms (table 7) was 2617 organisms/m^2, being maximum in post monsoon (3050org/m^2) and least in summer (1850 org/m^2). Chrionmids were dominant amongst benthic organisms with 2100 org/m^2 or 80.24% followed by molluscs 317org/m^2 or 12.11%, Chaoborus formed only 3.82% of total.

d) **Macrovegetation -** Observation on the occurrence of macrovegetation in the reservoir is presented in Table 8. Urmila Sagar showed moderate amount of mycrophytes, being 2.750 kg/m^2 wet weight and 0.115 kg/m^2 dryweight. Maximum 3.50 kg/m^2 mycrophytes were recorded in summer and least in post monsoon (1.750 kg/m^2). Aquatic weeds namely *Hydrilla, Valisnaria* and *Potomageton* were observed from the ecosystem.

4.4 Catch statistics :- The fishing rights of this reservoir too are auctioned to the contractor for the period of 3years with some specified increase from year to year basis..Urmila Sagar was auctioned for Rs. 2,22,786/- during 2002 -2003 with subsequent increase of 10% in first year and 12% in second year and 15% in third year. The responsibility of stocking and fishing is vested with the contractor during the contract period.It is mandatory for the contractor during the contract to stock the reservoir with prior information to the department of fisheries. Available stocking figures shows that there was no stocking of Urmila sagar during 1999-2000 and 2000-2001. However, during 2001 -2002 10 lakh and 2003 -2004, 9.80 lakh fingerlings were stocked. (table 13).Invariably fingerlings of Indian major carps has been stocked.

A total of 10t fish were caught during 2001-02 from this reservoir of which 50% were Indian major carps rest were minor carps and cat fish. In 2003-04 a total of 22t fish were caught. Indian major carps formed 63.63% of total catch followed by minor carps (22.72%) and rest others (Table 12). *Catla catla, L. rohita and C. mrigala* were the dominant species in catches. Cat fish *M. seenghala, W. attu* and murrels were also observed in catches.

4.5 Productivity status:-

The potential fish production kg ha^{-1} on the basis of carbon assimilation has been estimated as 220 kg/ha for Urmila Sagar against the actual production of 44.0 kg. The hydrological feature especially total alkalinity, specific conductance and concentration of calcium, magnesium and phosphate suggest the productive nature of the reservoir.

It is observed that stocking is confined to the release of fry of Indian major carps without paying adequate attention to biogenic capacity of the ecosystem. A sound management programme based on yield potential and availability of flood reserve is therefore needed. The rate of stocking resorted to, is unscientific and without any basis. It is also reported that sometimes the stocking of single species is resorted to, which results in waste of fish food reserve. It is recommended that the reservoir be stocked with IMC in the ratio of Catla4: Rohu3: Mrigal3 @ 500 fingerlings/ha. Efforts should be made to restrict the population of cat fish which otherwise reduces the production. Periodic harvesting is suggested to get optimum production.

5. Jaggar Reservoir :- (Fig.17-18).

5.1 Morphometric and hydrological characteristics:-

The morphometric and hydrological parameters of the Jaggar reservoir are presented in table 1.The reservoir is located at latitude 26°45'N and longitude 77°70'E in the Karoli district of Rajasthan on river Jaggar of Gambhiri river basin near Hindon city. It was constructed in 1957 and has got an area of 936.36 ha at FTL. The catchment area of the reservoir is spread over 227.82 km^2 and C/A ratio was 24.32. The reservoir is small and shallow with mean depth 4.3m and average annual rainfall of 400 mm. The catchment area lies primarily in dry Aravali rocky strata. Considering the morphometric and hydrological characteristics (Table 1) the reservoir is fairly productive.

5.2) Soil, water quality and productivity:-

a) **Soil Quality -** Observation on the physico-chemical characteristics of basin soil is presented in table 2. The soil texture is slightly loamy and alkaline with pH being 7.75. The organic carbon (0.29%), available phosphorus was 3.12 mg/100gm and available nitrogen was 9.87 mg/100g were of moderate range. The nutrient status of soil thus reflected a moderate productive nature of soil (Table 2).

b) **Water Quality -** The findings of water quality of the reservoir presented in the table 3. The mean surface temperature of water ranges between 18.0-31.0°C (mean 26.56 °C) and transparency ranged between, 20-120 cm (mean 66.67 cm). High turbidity during pre-monsoon period is attributed to the shallowness of reservoir coupled with high wind action.

c) The water was slightly alkaline (pH 7.82) which is congenial for fish growth. Free CO_2 range was 2.0-10.0 $mg1^{-1}$ (mean 7.0 $mg1^{-1}$). Dissolved oxygen content was in congenial range of 8.4-9.6 $mg1^{-1}$ with mean content of 9.14 $mg1^{-1}$.The value of DO was low in pre-monsoon and high in post- monsoon.The total alkalinity was above 116.0 $mg1^{-1}$ which indicates productive nature of reservoir.. Ionic concentration ranged between 264.0-394.0 µmhos/cm (mean 318.33µmhos/cm) also showed the productive character of the reservoir. Higher values of alkalinity in pre monsoon could be due to the reduced water level and more concentration of ions.

Average calcium concentration was 27.50 $mg1^{-1}$, magnesium ion which is an important component of chlorophyll was in moderate range of 12.0-15.0 $mg1^{-1}$ (mean 13.0 $mg1^{-1}$). Total hardness is reflected by the trends of magnesium in the reservoir. The range of chloride was 8.0-10.0 $mg1^{-1}$ (mean 9.09$mg1^{-1}$) and phosphate range 0.16-0.22$mg1^{-1}$ (mean 0.19$mg1^{-1}$) is favorable for fish production. The rich water quality reflects the transport of allochthonous dissolved nutrients and their leaching in to the system.

Depth wise observations in respect of Jaggar reservoir (table 3.5) did not show the presence of thermal stratification as the water temperature remained unchanged from surface to 8 m. depth in all the three seasons. However a weak chemical stratification has been observed in some period of the year.

c) **Primary productivity -** The findings on the estimation of primary production of Jaggar reservoir are presented in Table 4. The average gross production (mgC/m^3/

day) was estimated as 1354.08 and net production was 750.0. The assimilation efficiency was 53.39% which exhibited the productive nature of the reservoir.

5.3 Biotic communities:-

a) **Plankton** : The observation on the planktonic biomass and its composition is presented in table 5.The mean density of plankton was 1007u/l in Jaggar reservoir.Pre-monsoon season was rich in plankton population with 1104 u/l and winter was poor with 898 u/l. Copepods dominated the planktonic population with 32.89% (range 22.5-40.74 u/l) followed by Bacillariophyceae 22.51% (range 19.8-25.9%) and Chlorophyceae 13.76% (range 7.27-18.5). Phytoplankton and zooplankton population in Jaggar reservoir was almost equal (phytoplankton being 51.21% and zooplankton 48.50%). Copepods were dominant in the reservoir during winter (40.74%)Fig.19.

Microcystis was dominant constituent of blue green algae in Jaggar reservoir.

Synedera, Navicula, Tabellaria and Diatoma were commom diatoms observed.Copepods (*Cyclops, Diaptomus* and their nauplii) and cladocerous (*Daphnia*) formed the bulk of zooplankton.

b) **Periphyton** :- The mean periphytic population in Jaggar reservoir varied from 2712u/ cm^2 in pre-monsoon to 6075 u/cm^2 in winter with an average being 4241u/cm^2. Bacillariophyceae dominated with 69.86% followed by Chlorophyceae 18.03% and myxophyceae 12.10%. *Navicula, Cymbella, Fragillaria, Nitzschia Synedra Gomphonema, Chladophora, Cosmarium, Synedesmus, Anoebena, Merismopedia, Meridon* and *Spirulina* were dominant among the periphytic communities (Table 6,Fig.20).

c) **Macrobenthos:-** The standing crop of benthic organisms is presented in Table 7. Jaggar reservoir was poor in benthic organisms as only an average standing crop of 983 organisms/m^2 with Chironomids forming 71.22% of total. Chaoborus forming 15.25% and molluscs11.90%. Summer showed poor standing crop of 250 orgs/m^2 whereas it was 2150 org/m^2 in winter.

d) **Macrovegetation**:- Observation on the occurrence of macrovegetation in the reservoir is presented in Table 8. Macrophytes were absent in Jaggar reservoir during winter season. The macrovegetation was moderate 2.266 kg/m^2 wet weight in Jaggar. It was rich in macrovegetation during pre-monsoon (4.300 kg/m^2). Aquatic weeds namely *Hydrilla, Valisnaria* and *Potomageton* were recorded in the reservoir.

5.4 Catch statistics :- The fishing rights of this reservoir as also others, are auctioned to the contractor on the highest bid basis for a period of 3years with some specified increase from year to year basis. Jaggar reservoir was auctioned for Rs. 7,77,777/- during 2002 - 2003 with subsequent increase of 10% in first year and 12% in second year and 15% in third year. The responsibility of stocking and fishing is vested with the contractor during the contract period. It is mandatory for the contractor during the contract to stock the reservoir with prior information to the department of fisheries. Stocking of the reservoir ranged from 9.25 lakh (2000-03) to 19.20 lakh (2003-04) Table 13. There is no confirmation of size of stocked material. There is no basis of quantum of fish stocked. It is reported that invariably fingerlings of IMC are stocked.

Fig. 17 A view of Jaggar Reservoir

Fig. 18 Another view of Jaggar Reservoir

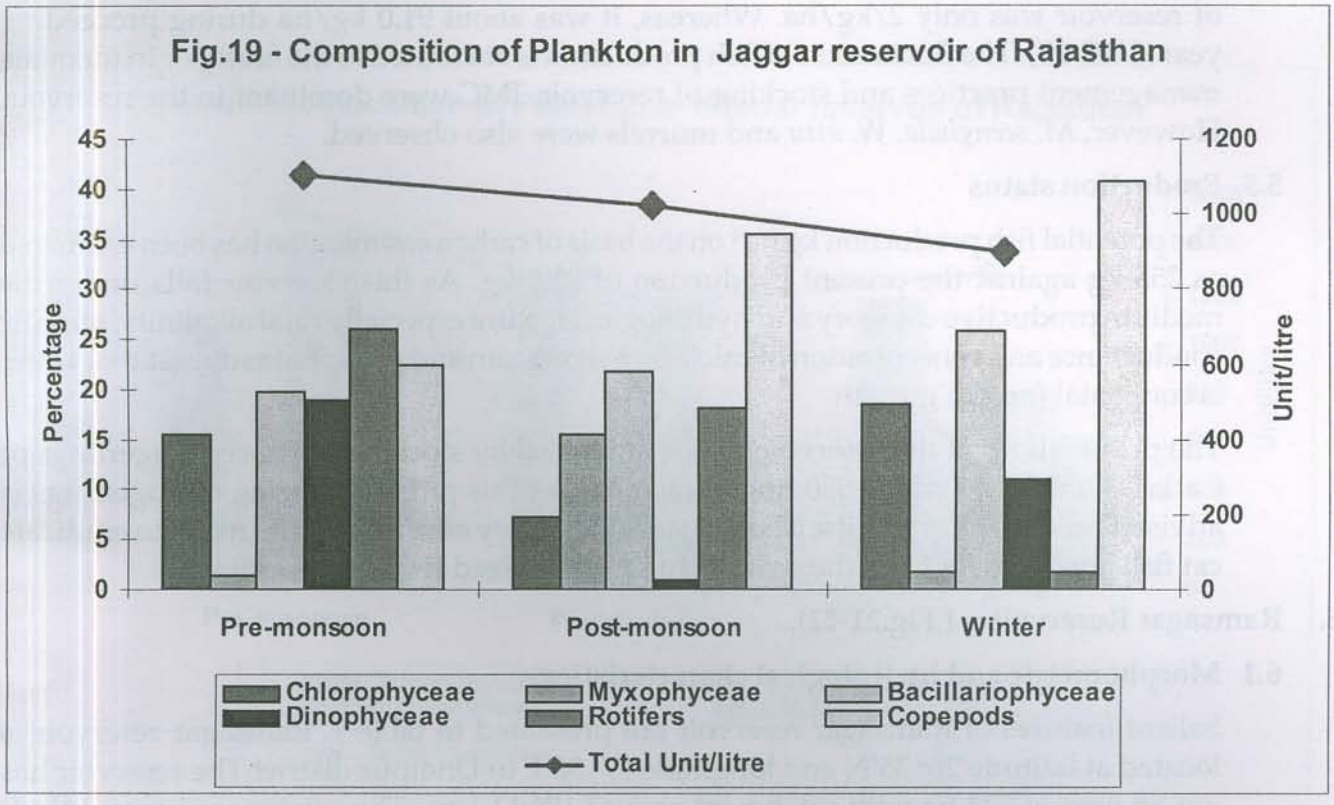
Fig.19 - Composition of Plankton in Jaggar reservoir of Rajasthan
Percentage
Unit/litre
45
40
35
30
25
20
15
10
5
0
1200
1000
800
600
400
200
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Dinophyceae
Myxophyceae
Rotifers
Bacillariophyceae
Copepods
Total Unit/litre

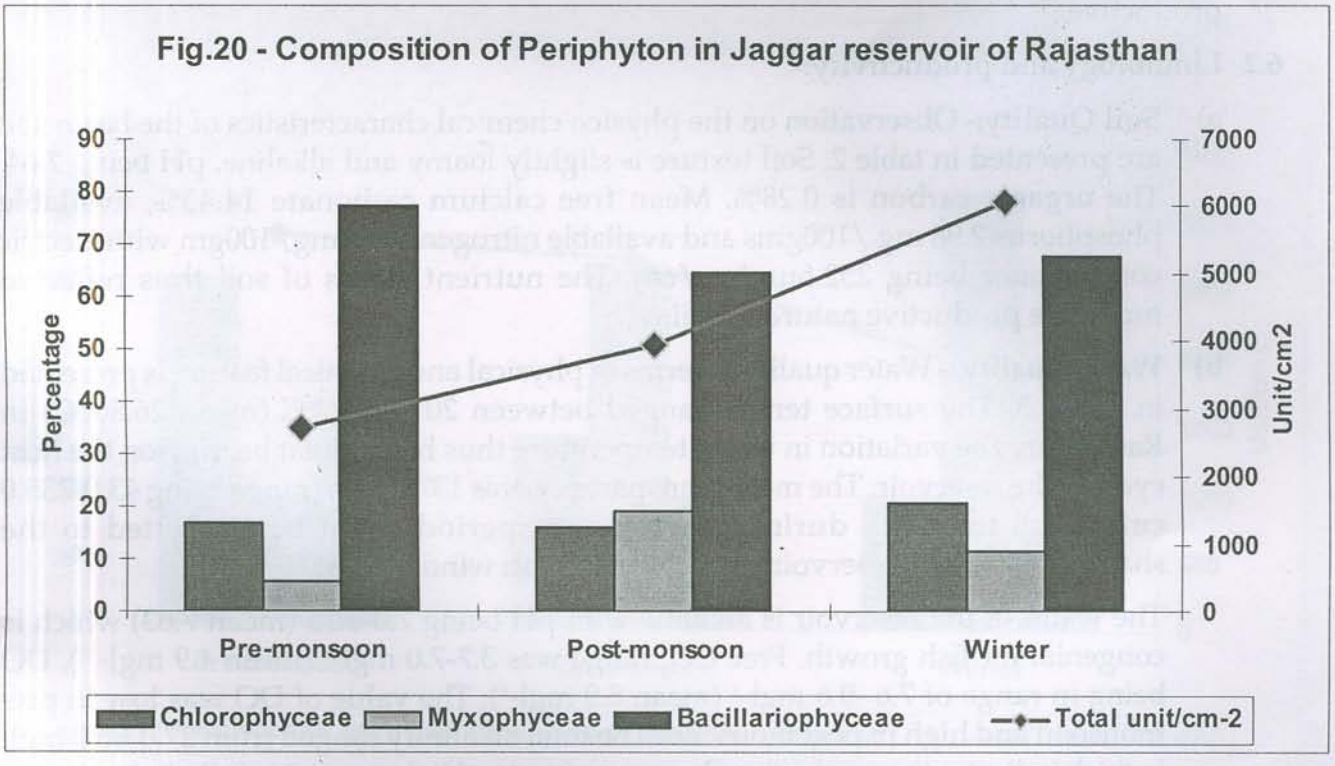
Fig.20 - Composition of Periphyton in Jaggar reservoir of Rajasthan
Percentage
Unit/cm2
90
80
70
60
50
40
30
20
10
0
7000
6000
5000
4000
3000
2000
1000
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Myxophyceae
Bacillariophyceae
Total unit/cm-2

The production from the reservoir shows (table 12) that during 2003-04 the production of reservoir was only 27kg/ha. Whereas, it was about 91.0 kg/ha during proceeding year (2002-03). The fluctuation of fish production is attributed to the faulty or inadequate management practices and stocking of reservoir. IMC were dominant in the reservoir. However, *M. seenghala, W. attu* and murrels were also observed.

5.5 Production status

The potential fish production kg ha^{-1} on the basis of carbon assimilation has been estimated as 255 kg against the present production of 91.0 kg. As this reservoir falls under the medium productive category and hydrological feature especially total alkalinity, specific conductance and concentration of calcium, magnesium and phosphate suggest that water is congenial for fish growth.

The productivity of the reservoir can be enhanced by stocking advanced fingerlings of Catla4: Rohu3: Mrigal3 @ 550 fingerlings/ha. For this purpose rearing of fingerlings is advised near the reservoir itself before stocking. Every effort should be made to eradicate cat fish and murrels from the ecosystem by specialized fishing operations.

6. Ramsagar Reservoir :- (Fig.21-22)..

6.1 Morphometric and hydrological characteristics:-

Salient features of Ramsagar reservoir are presented in table 1. Ramsagar reservoir is located at latitude 26° 35'N and longitude 77° 35'E in Dholpur district.The reservoir has got an area of 722 ha with catchment area of 176.11 km^2. The catchment/ area ratio is 24.39. It is very shallow reservoir with mean depth of 5m and average rainfall of 518.83 mm. The reservoir came up on the river Jangii and Brahmni, of Parvati river basin. Considering the morphometric and hydrological characteristics the reservoir is fairly productive.

6.2 Limnology and productivity:-

a) **Soil Quality:-** Observation on the physico chemical characteristics of the basin soil are presented in table 2. Soil texture is slightly loamy and alkaline. pH being 7.64. The organic carbon is 0.28%. Mean free calcium carbonate 14.43%, available phosphorus 2.98 mg /100gms and available nitrogen 10.91mg/100gm with electric conductance being 252.5µmhos/cm. The nutrient status of soil thus reflected moderate productive nature of soil.

b) **Water Quality :-** Water quality in terms of physical and chemical feature is presented in Table 3. The surface temp., ranged between 20.7-30.17°C (mean 26.86oC) in Ramsagar. The variation in water temperature thus had a great bearing on the heat cycle of the reservoir. The mean transparency was 137.66 cm (range being 43.0-235.0 cm). High turbidity during pre-monsoon period could be attributed to the shallowness of the reservoir coupled with high wind action.

The water of the reservoir is alkaline with pH being 7.0-8.15 (mean 7.63) which is congenial for fish growth. Free CO_2 range was 3.7-7.0 mgl^{-1} (mean 4.9 mgl^{-1}), DO being in range of 7.6 -9.6 mgl^{-1} (mean 8.9 mgl^{-1}). The value of DO was low in pre-monsoon and high in post monsoon. The total alkalinity ranged from 27.0-86.0 mgl^{-1} which indicates the productive character of water. Higher values of alkalinity during pre-monsoon and lower in winter could be due to reduced water level and thus

Fig. 21 A view of Ramsagar Reservoir

Fig. 22 Another view of Ramsagar Reservoir

more concentration of ions. Specific conductivity of water ranged between 223.5-256.7µmhos/cm (mean 236.67µmhos/cm). Specific conductivity shows the productive character of this reservoir.

The average calcium ions were 30.78mgl^{-1} & magnesium being 16.33 mgl$^{-1.}$ The moderate values of calcium and magnesium ions indicate productive nature of ecosystem. The average presence chloride 9.83 mgl^{-1} & available phosphate being 0.32mgl^{-1} which is favorable for fish growth. The rich water quality reflects the transport of allochthonous dissolved nutrients and their leaching into the system.

The observations (depth wise) in respect of Ram sagar reservoir (3.6) did not show any thermal stratification. There was difference of 1^{0}C from 2 to 4 m. depth and only 0.5^{0}C from 6 to 8 m. depth during winter. However a weak chemical stratification has been observed.

c) **Primary production:-** The observations on the primary productivity of the reservoir is presented in table 4.The average gross production of the reservoir (mgC/m^3 / day)was estimated to be 1312.44 whereas, net production to be 733.32 which exhibited moderate production. The assimilation efficiency was 55.87%.

6.3 Biotic communities:-

a) **Plankton:-**The observations on the study of planktonic biomass and its composition is presented in table5. The average density of plankton was 1609 u/l with myxophyceae dominating with 36.09% followed byBacillariophyceae 31.99%. Chlorophyceae formed 14.29% and rotifers were 14.0%. Bacillariophyceae (47.83%) dominated in pre-monsoon in Ramsagar whereas myxophyceae was dominant in winter. Microcystis was dominant in Ramsagar. The dominant forms of plankton were *Synedra, Navicula, Cymbella, Spirulina, Pediastrun, Chladophora, Characium, Fragillaria, Anabeana, Cosmarium, Scenedesmuss, Nitzschia, Diatoma, Merismopedia, Microcystis and Oscillatoria. The* occurance of *Oscillatoria, Microcystis and Pediastrum* indicated the *eutrophic* tendency of the ecosystem.(Fig.23).

b) **Periphyton -** The findings in respect of periphytic communities is presented in table 6. Winter months are richest in periphytic communities with 2450u/cm^2 followed by pre- monsoon (2380u/cm^2) and post-monsoon (1960u/cm^2),Fig.24. Average population of periphyton observed from Ramsagar reservoir is 2263 u/cm^2. Bascillariophyceae dominated with 51.97%. Chlorophyceae formed only 29.09% whereas myxophyceae was minimum with 18.99%. *Synedra, Tabellaria, Diatoma, Pediastrum, Chladophora, Characium, Fragellaria, Navicula, Anabeana, Cosmarium, Nitzschia, Merismopedia Cymbella* were the common forms observed from the reservoir.

c) **Macrobanthos -** The findings in respect of macrobenthos is presented in table 7. The standing crop of macrobenthos was maximum in winter (2250 organisms/m^2) and minimum in pre-monsoon (500organisms/m^2). Average benthos population was 1251 organisms/m^2 with dominance of Chironomids 917organisms/m^2 (73.35%) followed by Chaoborus larvae 225 organisms/m^2 (17.99%). Molluscs formed 6.73% only.

d) **Macrovegetation -** The finding in respect of macrovegetation is presented in table 8. In Ramsagar reservoir an average of 2.166 kg/m^2 of wet wt. and 0.208 kg/m^2 dry

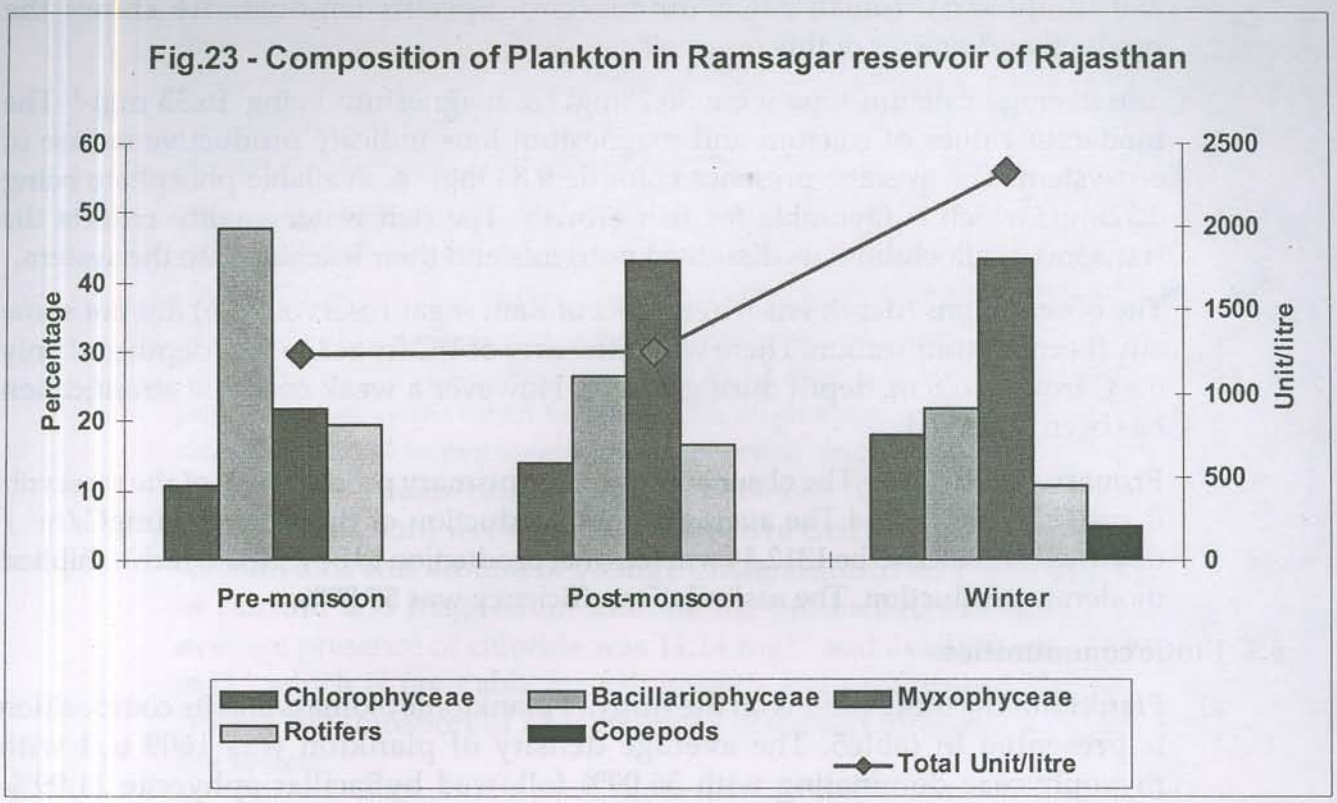
Fig.23 - Composition of Plankton in Ramsagar reservoir of Rajasthan
Percentage
Unit/litre
60
50
40
30
20
10
0
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Rotifers
Copepods
Total Unit/litre

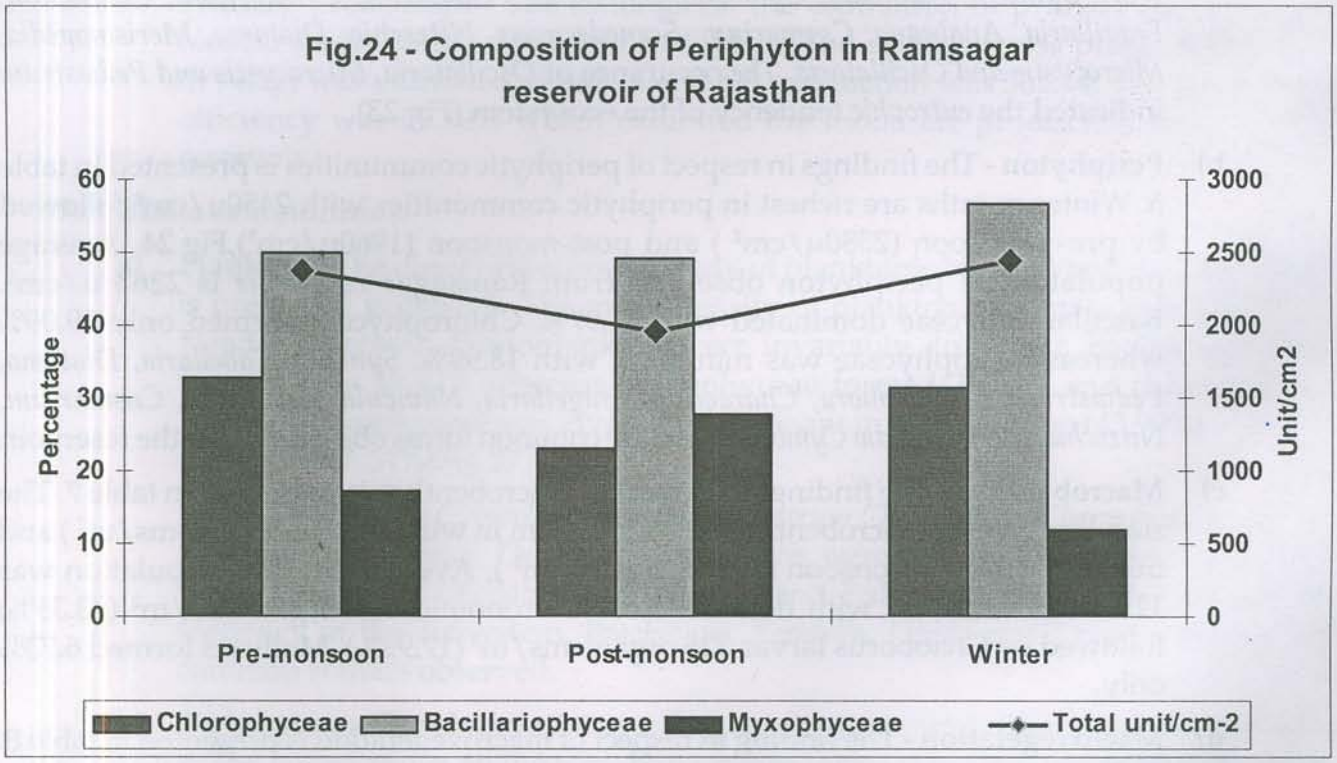
Fig.24 - Composition of Periphyton in Ramsagar reservoir of Rajasthan
Percentage
Unit/cm2
60
50
40
30
20
10
0
3000
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Total unit/cm-2

wt. of macrophytes were recorded. The dominant forms of macrophytes are *Hydrilla, Vallisneria, Potomogetan and Trapa*. The occurance of macrophytes were more in pre-monsoon (3.500 kg/m^2) and least in post-monsoon (1.250 kg/m^2).

6.4 Catch Statistics:-

As a policy matter Rajasthan fisheries department auction the fishable waters to the contractors for period of three years on annual increase basis. Contractors are responsible for stocking rearing and fishing operation under the supervision of Rajasthan fishery Deptt. The fishing is done by specialized fishing parties hired for the purpose by the contractors. No regular fishing is done through out the year. The lease amount for Ramsagar reservoir for 2004-05 was Rs 6,63,000/-. No stocking has been done in Ramsagar for 2003-04. However 500,000 fingerlings were stocked in 2004-05 (Table 14).

As for production of fish is concerned, during 2003-04, about 65,900 kg of fish, was caught, giving production of 91.27 kg/ha. No production figure is available for 2004-05 for the reservoir (Table 15).

6.5 Production status:- The production potential of Ramsagar is estimated at 204 kg/ha on the basis of carbon assimilation; against the present production of about 91.0 kg/ha.The hydrological feature especially total alkalinity, electric conductance and concentration of calcium, magnesium and phosphate suggest the productive nature of the reservoir.

At present the stocking of ecosystem is unscientific as the stocking is vested with the fish contractor, to whom water body is given for three years. The stocking is arbitrary and at times stocking of only one species is done thus a total wastage of time and resources. The ecosystem can be properly exploited and utilized if IMC in proper proportion is stocked at the rate of 900 fingerlings/ha (3 Catla: 2Rohu: 2Mrigala) in the size group of 50-75 mm, for which the stocking material be reared in pens near the reservoir itself. The auction period should be reviewed to give rest to the reservoir

7. Needar Reservoir :- (Fig.25-26)

7.1 Morphometric and hydrological characteristics:-

The morphometric and hydrological parameters of the Needar reservoir are presented in table 1.The reservoir is located at latitude 26°18'N and longitude 77°11'E in the Karoli district of Rajasthan and was constructed in 1956. It has got an area of 800 ha at FTL. The catchment area of the reservoir is spread over 46.62 km^2 with C/A ratio being 5.82. It is a shallow reservoir with mean depth of 5.0m. The average annual rainfall in the area is 675 mm. The water body is meant primarily for flood control and irrigation purpose. Considering the morphometric and hydrological characteristics (Table 1) the reservoir is fairly productive.

7.2 Limnology and productivity:-

a) **Soil Quality:-** Observation on the physico-chemical characteristics of basin soil is presented in table 2. The soil texture is slightly loamy and alkaline with pH being 7.94. The organic carbon is 0.43%, free calcium carbonate 23.5%, available phosphorus being 4.0 mg/100gm and available nitrogen being 14.72 mg/100g were in congenial range. The nutrient status of basin soil of the reservoir thus reflected a moderate productive nature of soil (Table 2).

b) **Water Quality:-** The findings of water quality of the reservoir is presented in the table 3. In Needar reservoir the surface temperature of water ranged between 20.4-28.6°C (mean 25.79°C). The variation in water temp. had a great bearing on the heat cycle of the reservoir. The transparency ranged between 42.5-109.0cm (mean 75.5 cm). High turbidity during pre-monsoon period is attributed to the shallowness of reservoir coupled with high wind action.

The water was alkaline (pH 7.82), pH ranged from 7.6-8.31, which is congenial for fish growth. Free CO_2 range was 6.0-12.0 $mg1^{-1}$ (mean 8.22 $mg1^{-1}$), dissolved oxygen content was in congenial range of 8.06-8.7 $mg1^{-1}$ with mean content of 8.34 $mg1^{-1}$. The value of DO was low in pre-monsoon and high in winter (8.7 $mg1^{-1}$). The average total alkalinity in the reservoir was 140.67 $mg1^{-1}$ (pre-monsoon) and 121.0 $mg1^{-1}$ in post monsoon with mean being 133.83. High values of alkalinity in pre-monsoon is due to reduced water levels in the reservoir and thus more concentration of ions. The ionic concentration ranged between 354.25-359.84µmhos/cm (mean 318.33µmhos/cm) which shows productive character of the reservoir. The average calcium ions was around 37.78 $mg1^{-1}$, magnesium17.12 $mg1^{-1}$. The moderate values of calcium and magnesium indicate the productive nature of the reservoir. The average presence of chloride was 11.14 $mg1^{-1}$ and available phosphorus being 0.37 $mg1^{-1}$ which is favorable for fish growth and production. The rich water quality reflects the transport of allochthonous dissolved nutrients and their leaching into the system.

The depth wise observations in respect of Needar reservoir do not show thermal stratification upto 4 m. depth (table 3.7). There is a weak chemical stratification as for D.O, free CO_2, total alkalinity and specific conductivity is concerned.

c) **Primary production:-** The findings on the estimation of primary production of Needar reservoir are presented in Table 4. The average gross production (mgC/m^3/day) was estimated as 942.24 and net production was 562.44. The assimilation efficiency was 59.70% which exhibited the moderate productive nature of the reservoir.

7.3 Biotic communities:-

a) **Plankton** : The observation on the study of planktonic biomass and its composition is presented in table 5. The mean density of planktonic biomass was 1312u/l in Needar reservoir. Phytoplankton were invariably dominant. Bacillariophyceae formed only 15.92% whereas myxophyceae formed 35.02% and chlorophyceae 36.08%. Myxophyceae was invariably dominant in pre-monsoon (43.90%) and post-monsoon (36.51%)Fig.27.

Navicula, Synedera Cymbella, Spirulina,Pediastrum,Chla dophora,Characium, Fragillaria, Anabeana, Cosmarium, Oscillatoria,Microcystis were the dominant forms observed. The occurance of *Oscllatoria, Mycrocystis* and *Pediastrum* indicated the eutrophic tendency of the ecosystem. *Brachionus, Keratella, Filinia* and *Trichocerca* were the common rotifers observed.

b) **Periphyton :-** The observations on the periphytic communities is presented in table 6. The observations on the periphytic communities was observed to be 2497u/cm^2. Bacillariophyceae with 44.83% dominated the periphytic population followed by

Fig. 25 A view of Needar Reservoir

Fig. 26 Another view of Needar Reservoir

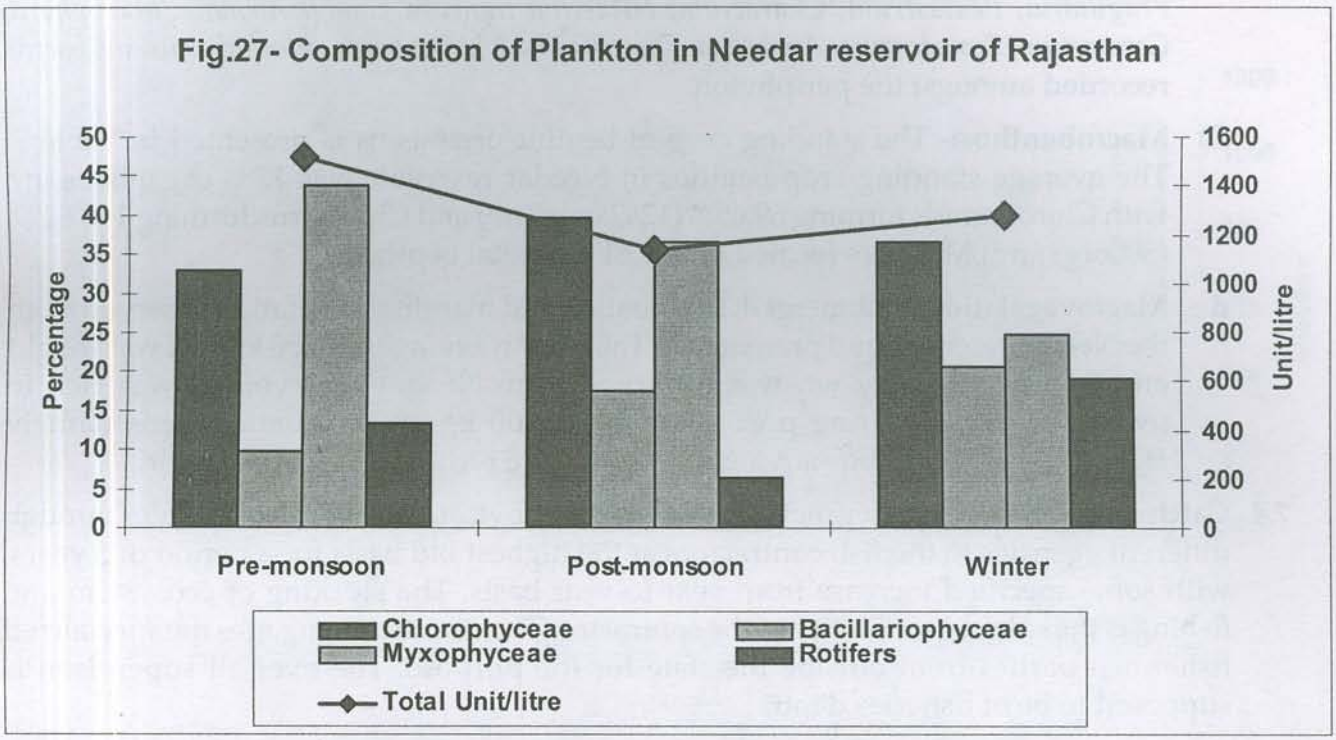
Fig.27- Composition of Plankton in Needar reservoir of Rajasthan
Percentage
Unit/litre
50
45
40
35
30
25
20
15
10
5
0
1600
1400
1200
1000
800
600
400
200
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Rotifers
Total Unit/litre

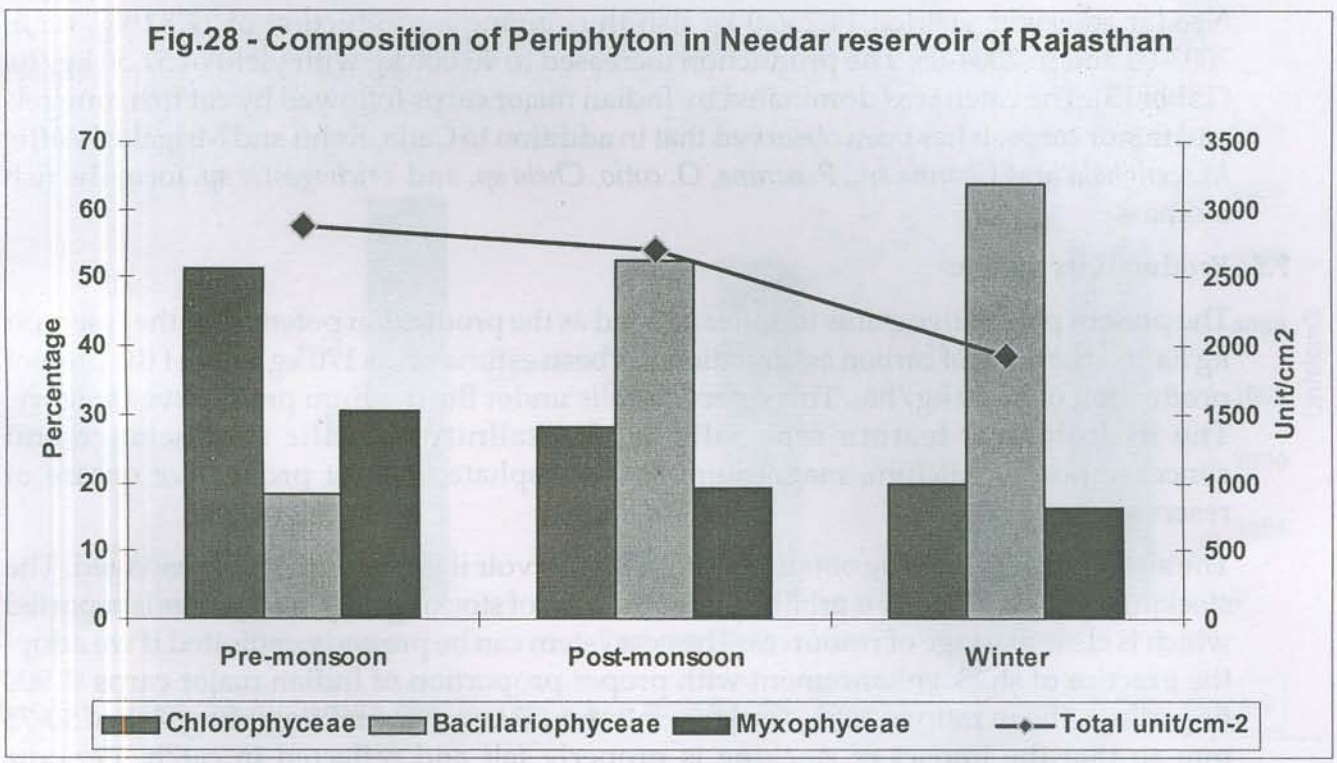
Fig.28 - Composition of Periphyton in Needar reservoir of Rajasthan
Percentage
Unit/cm2
70
60
50
40
30
20
10
0
3500
3000
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Total unit/cm-2

Chlorophyceae (33.14%) and myxophyceae 22.03%. Pre-monsoon season was richest with 2870u/cm² as compared to winter (1925u/cm²)Fig.28.. *Navicula, Cymbella, Fragillaria, Pediastrum, Characium, Nitzschia Synedra Gomphonema, Chladophora, Cosmarium, Synedesmus, Anabeana, Diatoma and Merismopedia* were dominant forms recorded amongst the periphyton.

C) **Macrobenthos:-** The standing crop of benthic organisms is presented in Table 7. The average standing crop benthos in Needar reservoir was 1783 organisms/m² with Chironomids forming 69.65% (1242 orgs/m²) and Chaoborus forming 116.82%, (300orgs/m²),Molluscs formed only 5.61% of total benthos.

d **Macrovegetation:-** Submerged, free floating and marginal vegetation observed from the Needar reservoir and presented in Table 8. An average of 2.350 kg/m2 wet weight and 0.150 kg/m² dry wt. was observed from Needar reservoir. It was rich in macrovegetation during post-monsoon (2.500 kg/m²). Aquatic weeds namely *Hydrilla, Valisnaria, Potomageton and Trapa* were recorded in the reservoir.

7.4 Catch statistics :- As a policy matter the Rajasthan Govt. auction its fishable water through different agencies to the fish contractors at the highest bid basis for a period of 3 years; with some specified increase from year to year basis. The stocking of ecosystem and fishing is the sole responsibility of the contractor. The contractor engages the specialized fishermen parties from outside the state for the purpose. The over all supervison is supposed to be of fisheries deptt.

Needar reservoir was auctioned for Rs. 5,54,400/- during 2004 -05 with subsequent increase of 10% in first year and 12% in second year and 15% in third year. Stocking of the reservoir was 18,50,000 (2003-04) and 14,50,000 (2004-05) (Table 14.) The stocking is reported to be of IMC in varying proportions.

Needar reservoir yielded 14,256.0 kg fish thus giving a production of 17.82 kg/ha in 2003-04 and in 2004-05. The production increased to 46,000 kg with yield of 57.50 kg/ha (Table 15). The catch was dominated by Indian major carps followed by cat fish, murrels and minor carps. It has been observed that in addition to Catla, Rohu and Mrigala; *W.attu, M.seenghala* and *Channa sp., P. sarana, O. cotio, Chela sp.* and *Trichogester sp.* form the fish biomass

7.5 Productivity status:-

The present productive status is under utilized as the production potential of the reservoir kg ha^{-1} on the basis of carbon assimilation has been estimated as 170 kg against the present production of 57.50 kg/ha.. This reservoir falls under the medium productive category. The hydrological feature especially total alkalinity, specific conductance and concentration of calcium, magnesium and phosphate suggest productive nature of reservoir.

The sustained yield can be obtained from the reservoir if it is scientifically managed. The stocking by the contractor is arbitrary as at the time of stocking only one species is reported which is clear wastage of resources. The ecosystem can be properly exploited if we adopt the practice of stock enhancement with proper proportion of Indian major carps @ 900 fingerlings/ha in ratio of 3:2:2. The stocking should be advanced fingerling size of 50-75 mm so that the impact of stocking is properly felt and reflected in catch. Periodic harvesting is suggested to get optimum yield.

Fig. 29 A view of Mamchari Reservoir

Fig. 30 Another view of Mamchari Reservoir

8. Mamchari Reservoir :- (Fig.29-30).

8.1 Morphometric and hydrological characteristics:-

The morphometric and hydrological parameters of the Mamchari reservoir are presented in table 1.The reservoir is located at latitude 27°15'N and longitude 76°55'E in the Karoli district of Rajasthan. It was constructed in 1963 on river Nami and has a water spread area of 400 ha. The catchment area of the reservoir is 30.61 km^2 with C/A ratio being 7.65. The reservoir is very shallow with mean depth of 4.0m. The average annual rainfall in the area is 675 mm. The water body is meant primarily for flood control and irrigation purpose. The morphometric and hydrological characteristics the reservoir shows it to be fairly productive ecosystem.

8.2 Limnology and productivity:-

a) **Soil Quality:-** Observation on the physico-chemical characteristics of basin soil is presented in table 2. The basin soil is slightly loamy and alkaline with pH being 7.75. The organic carbon (0.26%), available phosphorus being 2.72 mg/100gm and available nitrogen 12.5 mg/100g and electric conductance (255.5 µmhos/cm) were all in congenial range. The nutrient status of basin soil of the reservoir reflected a moderate productive nature of soil.

b) **Water Quality**:- The findings of water quality of the reservoir presented in the table 3. In Mamchari reservoir the surface temperature of water ranged between 18.7-29.0°C (mean 25.23°C). The variation in water temp. had a great bearing on the heat cycle of the reservoir. The transparency ranged between 75.0-245.0cm (mean 134.17 cm). High turbidity during pre-monsoon period is attributed to the shallowness of reservoir coupled with high wind action.

The water was alkaline (pH 7.99), pH ranged between 7.83-8.15, which is congenial for fish growth. Dissolved oxygen mean was 8.5 $mg1^{-1}$ (range 7.95-9.3), free CO_2 ($mg1^{-1}$) range was 6.4-7.0 $mg1^{-1}$ (mean 6.63 $mg1^{-1}$) and total alkalinity average 86.63 $mg1^{-1}$ (82.0-89.7). The high value of alkalinity in pre-monsoon is due to the reduced water level in the reservoir and more concentration of ions. The ionic concentration ranged between 208.5-222.0µmhos/cm (mean 215.01µmhos/cm) which shows productive character of the reservoir.

The average calcium ions was around 31.80 $mg1^{-1}$, magnesium being 15.40 $mg1^{-1}$. The moderate values of calcium and magnesium indicate the productive nature of the reservoir. The average presence of chloride was 11.08 $mg1^{-1}$ and available phosphorus being 0.35 $mg1^{-1}$, silicate 1.24 $mg1^{-1}$ which is favorable for fish growth and production. The rich water quality reflects the transport of allochthonous dissolved nutrients and their leaching into the system.

The depth wise observations in respect of Mamchari reservoir show no thermal as well as chemical stratification (table 3.8). Mixing of water because of shallowness of reservoir might have prevented formation of thermocline.

c) **Primary production:-** (Table 4) The average gross production ($mgC/m^3/day$) was estimated as 1666.68 and net production was 1016.64. The assimilation efficiency was 60.99% which exhibited the productive nature of the reservoir.

8.3 Biotic communities:-

a) **Plankton** : The observation on the study of planktonic biomass and its composition is presented in table 5.

The average density of planktonic biomass was 1797u/l in Mamchari reservoir. Bacillariophyceae with 41.98% dominating the population followed by myxophyceae (31.40%) and chlorophyceae (17.01%).Rotifers formed 8.40% and copepods 0.21%. Pre-monsoon was richest in planktonic population with 2257 u/l. followed by post-monsoon (1667u/l) and winter 1468 u/l. Bacillariophyceae invariably dominated through out the year(Fig.31). In Mamchari reservoir *Synedra* dominated in post-monsoon season.

Navicula, Synedera, Pediastrum, Oscillatoria, Microcystis, Diatoma, Brachionus, Karatella, Trichocerca, Cyclops, Diaptomus, Naupulli, were the dominant plankton forms observed. The occurance of *Oscllatoria, Mycrocystis* and *Pediastrum* indicated the eutrophic tendency of the ecosystem.

b) **Periphyton** :- The observations on the periphytic communities is presented in table 6. Mamchari reservoir showed an average of 3637 u/cm^2 of pryphytone. Bacillariophyceae with 50.73% dominated the periphyton, followed by Chlorophyceae (38.46%) and myxophyceae 10.81%. Pre-monsoon season was richest with 4340u/cm^2 followed by post-monsoon (3360u/cm^2) and winter (3310 u/cm^2)Fig.32.. *Navicula, Cymbella, Fragillaria, Pediastrum, Characium, Nitzschia Synedra Chladophora, Cosmarium,, Anabeana, Diatoma and Marimopedia* were dominant forms recorded amongst the periphyton.

c) **Macrobenthos**:- The standing crop of benthic organisms is presented in Table 7. The average standing crop of benthic organisms was estimated to be, 483 organisms/ m^2 for Mamchari reservoir. The thin population of the benthic organisms is due to rocky strata of the reservoir. Dipteran larvae invariably formed the bulk with 79.29% of total. Chironomids alone forming 58.59%. Molluscs observed were only shells. Post monsoon season was richest in benthic organisms.

d) **Macrovegetation:-** (Table 8) An average of 2.233kg/m2 of macrovegetation was recorded from the reservoir with almost uniform presence in all the three seasons. The dominant macrophytes observed are *Hydrilla, Valisnaria, Potomageton and Trapa.*

8.4 Catch statistics :- As a policy matter the Rajasthan Govt. auction its fishable water through different agencies to the fish contractors at the highest bid basis for a period of 3 years; with some specified increase from year to year basis. The stocking of ecosystem and fishing is the sole responsibility of the contractor. The contractor engages the specialized fishermen parties from outside the state for the purpose. The over all supervison is supposed to be of fisheries deptt.

The lease amount of the Mamchari reservoir during 2004-05 was Rs. 1,95,356/-. Stocking of the reservoir during 2003 -04 to the tune of 1,65,000 fingerlings and 2004-05 only 27000 fingerlings was done (Table 14&15).

Production of fish from Mamchari reservoir during 2003-04 was 18256 kg giving a production 45.64 kg/ha whereas it rose to 55500 kg or 138.75 kg/ha during 2004-05. The catch was dominated by Indian major carps followed by cat fish and murrels.

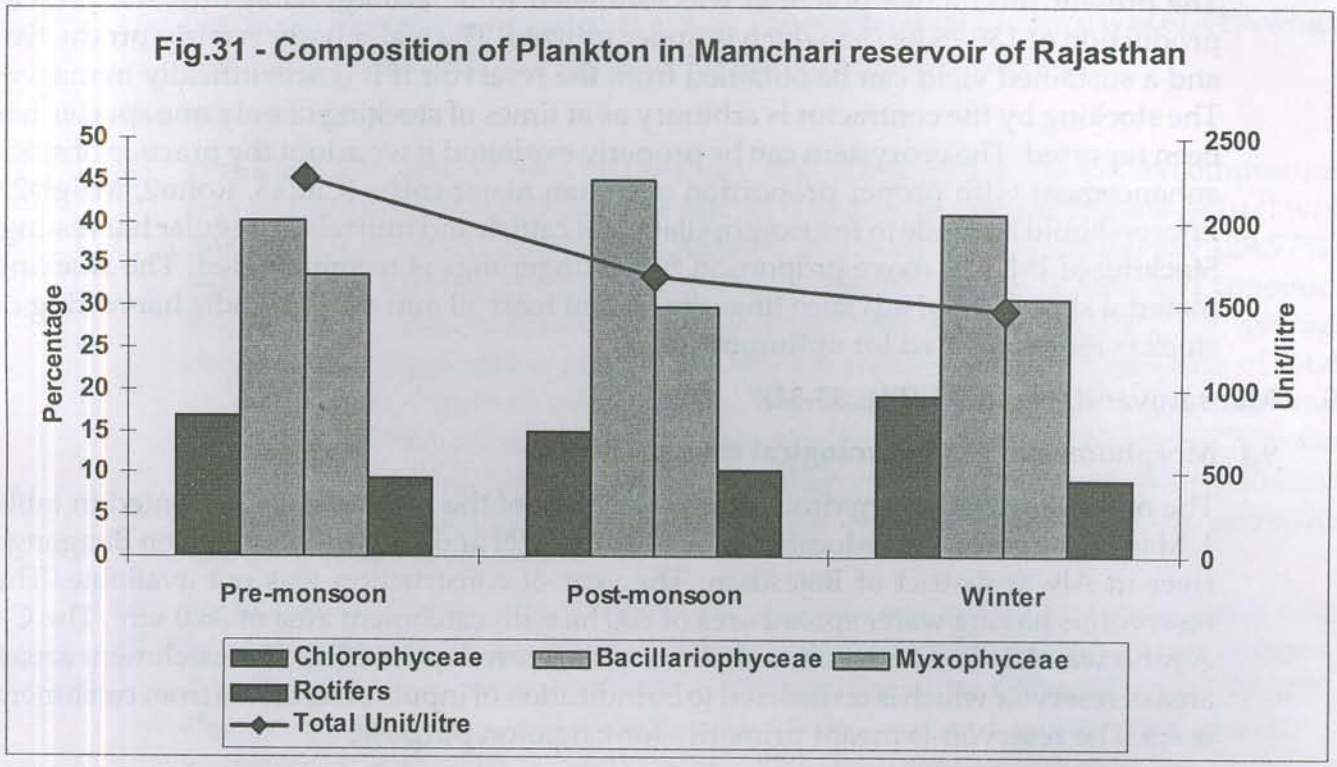
Fig.31 - Composition of Plankton in Mamchari reservoir of Rajasthan
Percentage
Unit/litre
50
45
40
35
30
25
20
15
10
5
0
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Rotifers
Total Unit/litre

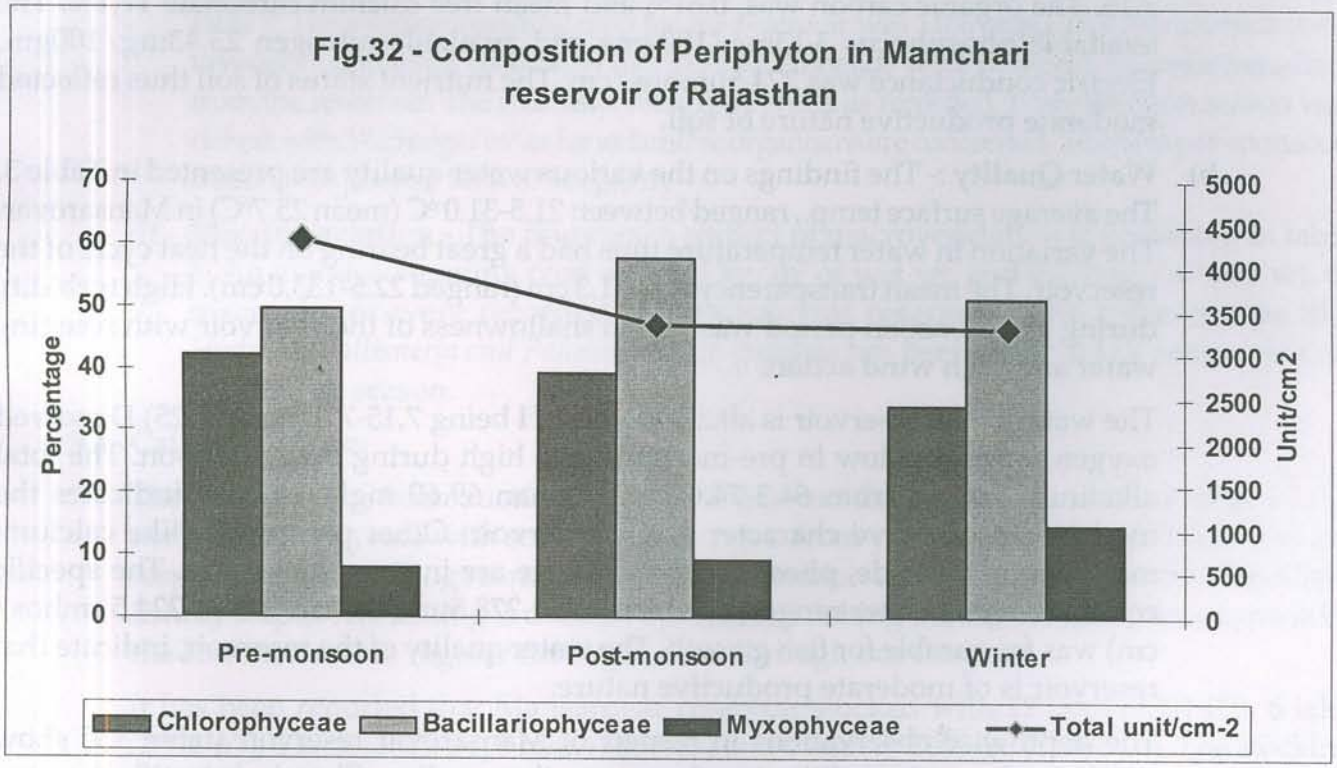
Fig.32 - Composition of Periphyton in Mamchari reservoir of Rajasthan
Percentage
Unit/cm2
70
60
50
40
30
20
10
0
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Total unit/cm-2

8.5 Productivity status:-

The present productive potential was estimated to be 276 kg/ha against the present production of 138.75 kg/ha which is under utilized. The water body is fairly productive and a sustained yield can be obtained from the reservoir if it is scientifically managed. The stocking by the contractor is arbitrary as at times of stocking of only one species has been reported. The ecosystem can be properly exploited if we adopt the practice of stock enhancement with proper proportion of Indian major carps (Catla3, Rohu2, Mrigla2). Efforts should be made to restrict population of catfish and murrels by regular harvesting. Stocking of IMC in above proportion @ 900 fingerlings is recommended. The stocking material should be of advance fingerlings of at least 50 mm size. Periodic harvesting of stock is recommended for optimum yield.

9. Mansarovar Reservoir :- (Fig. 33-34).

9.1 Morphometric and hydrological characteristics:-

The morphometric and hydrological parameters of the reservoir are presented in table 1. Mansarovar reservoir is located at latitude 27° 14'N and longitude 76° 26'E on Banganga river in Alwar district of Rajasthan. The year of construction was not available. The reservoir is having water spread area of 800 ha with catchment area of 36.0 km^2. The C/A ratio was 4.5. The reservoir is shallow with mean depth of 5m. The catchment area/area of reservoir which is considered to be indication of inputs of nutrients from catchment is 4.5. The reservoir is meant primarily for irrigation purpose.

9.2 Limnology and productivity:-

a) **Soil Quality**:- Observation on the physico-chemical characteristics of the basin soil are presented in table 2. Soil texture is slightly loamy and alkaline with pH being 7.15. The organic carbon was, 0.61% and mean free calcium carbonate 17.1%. The available phosphorus 3.13mg/100gms and available nitrogen 23.43mg/100gm. Electric conductance was 224.5µmhos/cm. The nutrient status of soil thus reflected moderate productive nature of soil.

b) **Water Quality** :- The findings on the various water quality are presented in Table 3. The average surface temp., ranged between 21.5-31.0 °C (mean 25.7°C) in Mansarovar. The variation in water temperature thus had a great bearing on the heat cycle of the reservoir. The mean transparency was 81.3 cm (ranged 22.5-133.0 cm). High turbidity during pre-monsoon period was due to shallowness of the reservoir with receding water and high wind action.

The water of the reservoir is alkaline with pH being 7.15-7.4 (mean 7.25).Dissolved oxygen range was low in pre-monsoon and high during post-monsoon. The total alkalinity ranged from 64.3-74.6 mgl^{-1} (mean 69.60 mgl^{-1}) which indicates the moderate productive character of the reservoir. Other parameters like calcium, magnesium, chloride, phosphate and silicate are in congenial range. The specific conductivity of water ranged between 158.0-278.5µmhos/cm (mean 224.5µmhos/cm) was favourable for fish growth. The water quality of the reservoir, indicate that reservoir is of moderate productive nature.

The depthwise observations in respect of Mansarovar reservoir (table 3.9) show nearly isothermal conditions as there is no thermocline. Chemical stratification too has not been observed which is attributed to the shallowness of the reservoir.

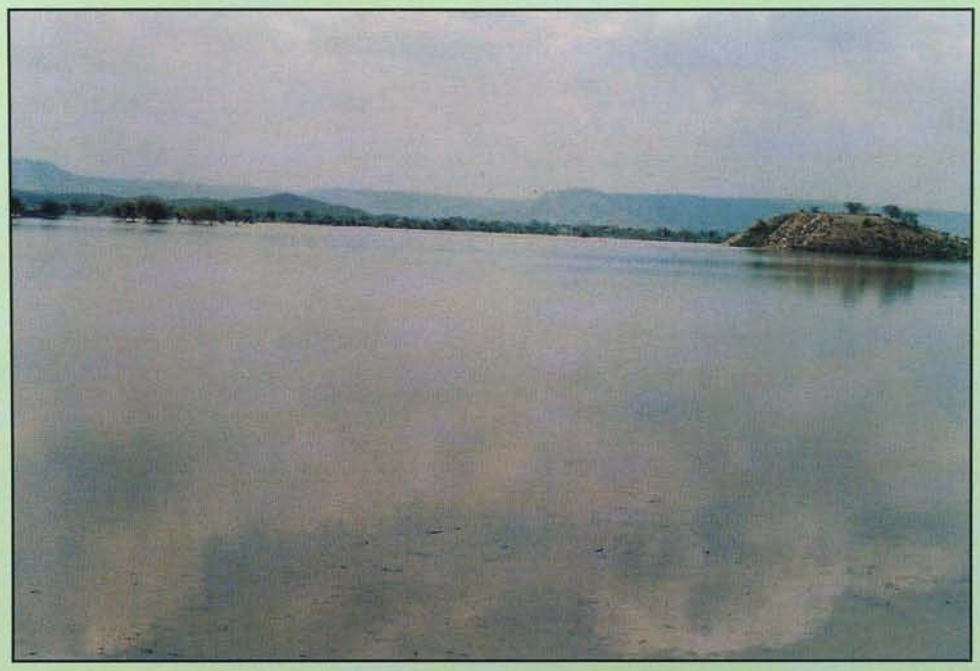

Fig. 33 A view of Mansarovar Reservoir

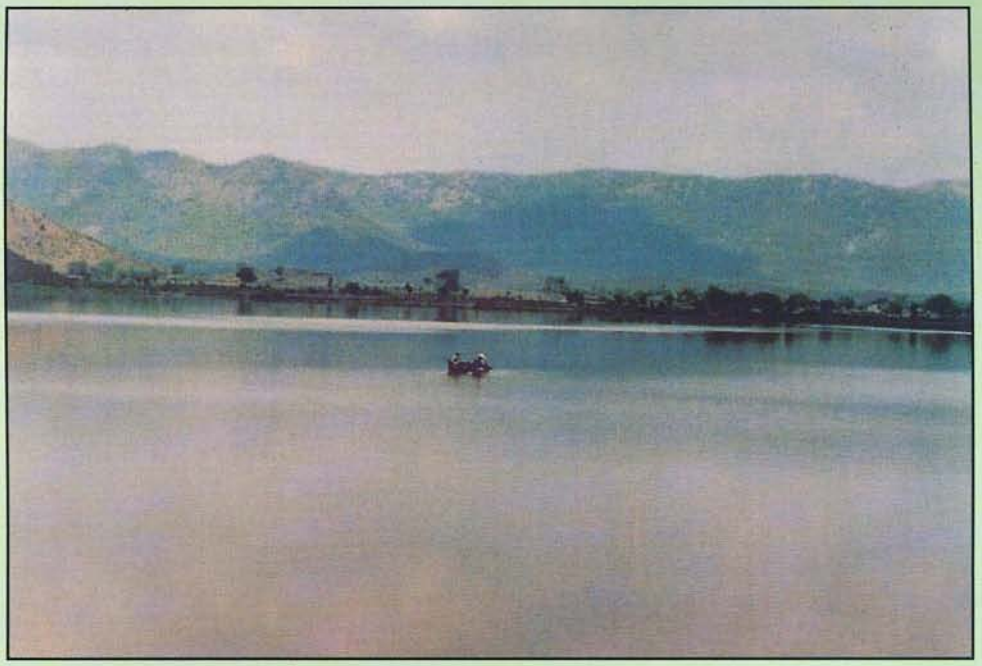

Fig. 34 Another view of Mansarovar Reservoir

c) **Primary production :-**(Table 4)The observations on the primary productivity of the reservoir show gross average production (GP) mgC/m^3/day was 617.24 where as net production was essimilated at 379.28. The conversion efficiency was 61.44% which was fairly high exhibiting productive character of the reservoir.

9.3 Biotic communities:-

a) **Plankton**:-The observations on the study of planktonic biomass and its composition is presented in table 5. The average density of plankton population was 881u/l with dominance of Bacillariophyceae 46.94% followed by Myxophyceae (29.97%). Zooplankton formed 10.15% total of which, Rotifers formed 6.62% and copepods 3.53%. Post monsoon season was rich in plankton (973 u/l).Fig.35. The average density of phytoplankton population was invariably more being 89.86% of total. Chlorophyceae formed only12.94%. The dominant forms of plankton were *Synedra,Tabellaria,Cyclops, Brachionus, Novicula, Cymbella, Spirulina, Spirogyra, Meridion Pediastrun, Anabeana, Scenedesums, Diatoma, Merismopedia, Mycrocystis and Oscillatoria. The* occurance of *Oscillatoria, Microcystis and Pediastrum* indicated the eutrophic tendency of the ecosystem.

b) **Periphyton -** The findings in respect of periphytic communities is presented in table 6. An average of 1622 u/cm^2 of periphyton were observed from Mansarovar reservoir. Bascillariophyceae dominated with 70.27% followed by Chlorophyceae (23.23%). Pre-monsoon season was richest with 1960u/cm^2 and winter was poorest in periphyton with 1260 u/cm^2.(Fig.36). The dominant periphyton are *Cymbella, Ulothrix, Synedra, Chladophora, Characium, Fragellaria, Microcystis, Meridion, Gyrosigma Navicula, Nitzschia, Cymbella* were the common forms observed from the reservoir.

c) **Macrobanthos -** The composition of benthic organisms from the reservoir is presented in table 7. The average standing crop for the reservoir was 1166 orgs/m^2. Chironomids were invariably dominant 8830 orgs/m^2 (75.72%). Annelids were observed (67 organisms/m^2) from the reservoir. The mollusks were only shells as recorded. Post-monsoon season was richest with 1825 orgs/m^2 as for as benthic organisms are concerned, where as pre-monsoon season was poorest with 675 orgs/m.

d) **Macrovegetation -** The findings in respect of macrovegetation is presented in table 8. An average standing crop of 3.800 kg/m^2 of wet wt. and 0.236 kg/m^2 dry wt. of macrophytes were recorded for Mansarovar reservoir.. The macrophytes like *Hydrilla, Vallisneria and Potomogeton* in patches has been observed in post-monsoon and winter season.

9.4 Catch Statistics:-

The reservoir has been auctioned by the Rajasthan fisheries to the highest bidder for a period of three years with some fixed increase from year to year basis. Contractors are responsible for stocking rearing and fishing operation under the supervision of Rajasthan fishery Deptt. The fishing is done by specialized fishing parties hired for the purpose by the contractors. No regular fishing is done through out the year.

It has been reported that Mansarovar reservoir stocked with 17 lakh (2001-02), 6 lakh (2002-03), 4 lakh (2003-04) 5 lakh (2004-05) and 4 lakh in 2005-06 (Table 16). The stocking of IMC have been reported.

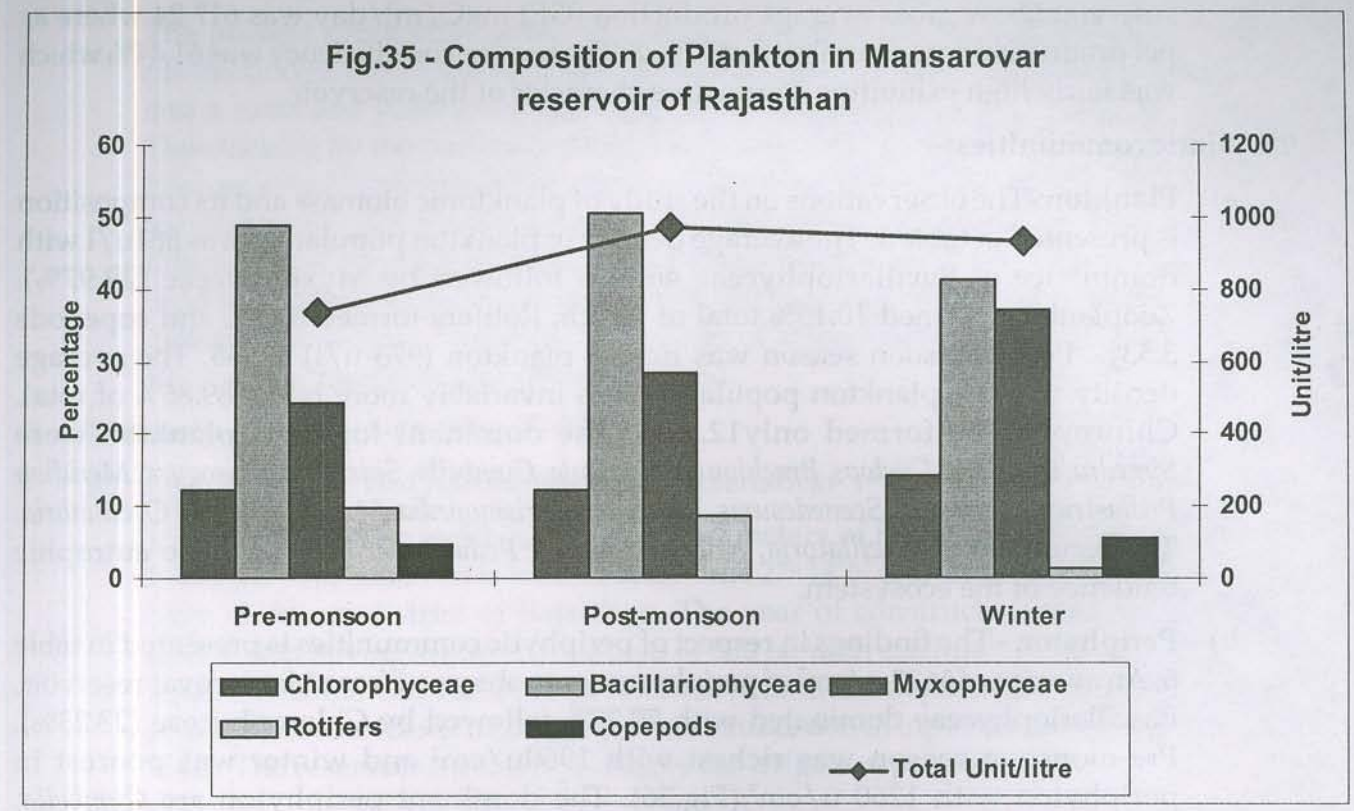
Fig.35 - Composition of Plankton in Mansarovar reservoir of Rajasthan
Percentage
Unit/litre
60
50
40
30
20
10
0
1200
1000
800
600
400
200
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Rotifers
Copepods
Total Unit/litre

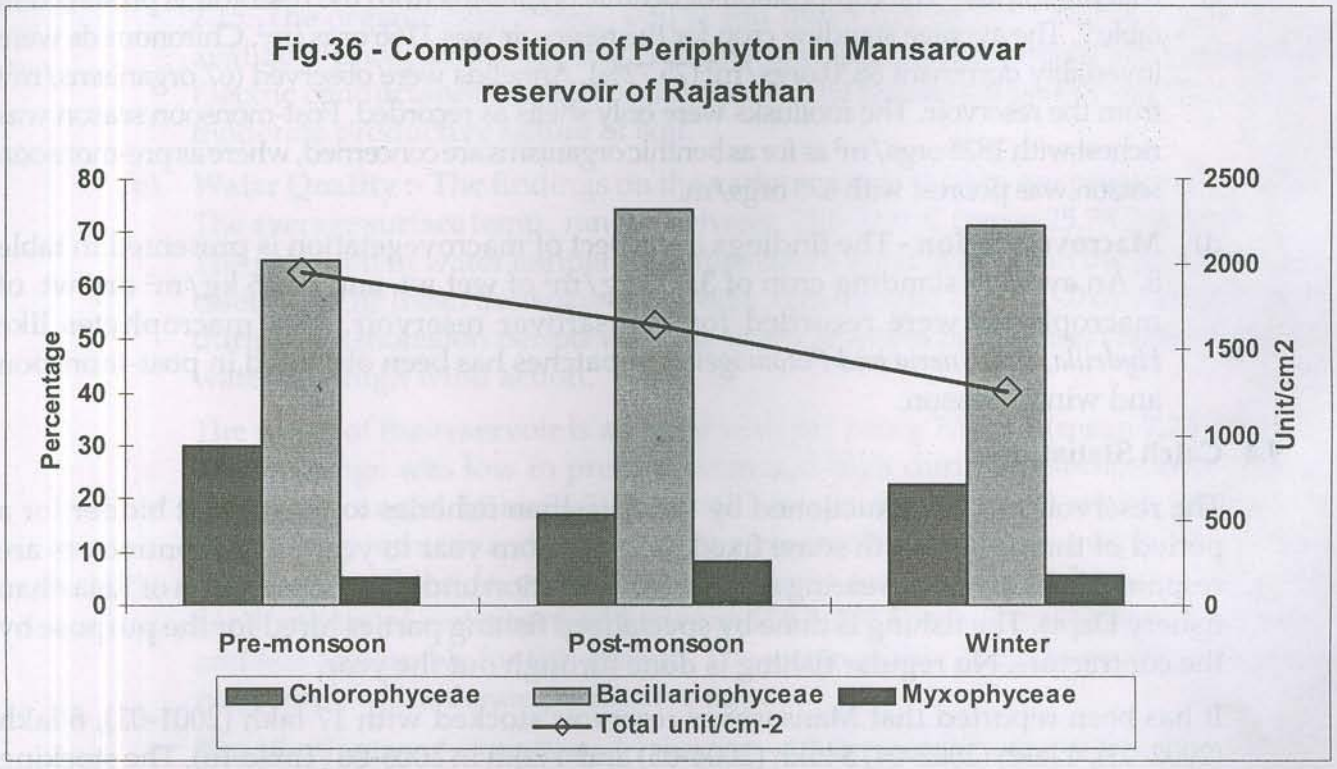
Fig.36 - Composition of Periphyton in Mansarovar reservoir of Rajasthan
Percentage
Unit/cm2
80
70
60
50
40
30
20
10
0
2500
2000
1500
1000
500
0
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Total unit/cm-2

The catch composition from 2001-02 to2005-06 is presented in table 17. Higher production of 43.12 kg/ha was achieved in 2003-04. During 2004-05 IMC formed 65.87% of total fish catch; followed by minor carps (15.48%), cat fish (9.92%).

9.5 Production Status :- The production potential of Mansarovar reservoir is estimated at 129.0 kg/ha on the basis of carbon assimilation; against the present production of about 43.12 kg/ha.

It is recommended that for getting a sustained yield from the reservoir, stocking of 500 advanced fingerlings/ha of IMC (4 Catla: 3Rohu: 3Mrigala) is essential. Periodic harvesting of the fish stock is recommended to get optimum yield.

10. Harsora Reservoir :- (Fig.37-38)

10.1 Morphometric and hydrological characteristics:-

The morphometric and hydrological parameters of the reservoir are presented in table 1. Harsora reservoir is located at latitude 27° 48'N and longitude 76° 28'E on river Sabi in Alwar district of Rajasthan. The reservoir has got water spread area of 400 ha with catchment area of 31.0 km^2. The C/A ratio was 7.75. The C/A ratio indicates the inputs of nutrients through catchment area. The reservoir is shallow with mean depth of 4m.

10.2 Limnology and productivity:-

a) **Soil Quality**:- Observation on the physico-chemical characteristics of the basin soil are presented in table 2. The soil is loamy with sand, silt and clay being 52.55,32.70 and 14.82% respectively. Average pH was7.03 and average available phosphorus and available nitrogen being 2.95 and 19.67mg/100gm respectively. The specific conductivity of basin soil was 272.5µmhos/cm. The nutrient status of soil thus reflected moderate productive nature of soil.

b) **Water Quality :-** The observations on the various parameters of water quality are presented in Table 3. The average surface temp. ranged between 20.2-30.5 °C (mean 24.17°C) in Harsora reservoir. The variation in water temperature thus had a great bearing on the heat cycle of the reservoir. The mean transparency was 23.0 cm (ranged 11.0-32.5 cm). The high turbidity during pre-monsoon period could be attributed to the shallowness of the reservoir coupled with turbulence due to high wind action.

The water of the reservoir was near neutral with pH ranging between 6.8-7.0 (mean 6.9) due to which the fish growth is inhibited..Dissolved oxygen was in congenial range of 6.8-9.2 mgl^{-1} (mean 8.03 mgl^{-1}).Free CO_2 was nil-8.0 mgl^{-1} (mean 4.67 mgl^{-1}). The total alkalinity ranged from 69.5-89.0 mgl^{-1} (mean 79.17 mgl^{-1}) with specific conductance in the range of 129.0-154.7 µmhos/cm (mean 145.92µmhos/cm) which reflect the moderate productive nature of the reservoir. The calcium ions, phosphate, silicate and chloride were 26.17, 0.22, 1.05 and 13.08 mgl^{-1} which depicts the moderate productive nature of water. The over all water quality indicates that the reservoir is of moderate productive nature.

In Harsora reservoir (table 3.10) nearly isothermal conditions have been observed as no thermal stratification has been observed. There is weak chemical stratification in the reservoir.

c) **Primary production:-**The findings on the primary productivity are presented in table 4. Gross production (mgC/m^3/day) was estimated at 586.12 net production was 348.82. The conversion efficiency was 59.51%. The values project a moderate productive nature of the reservoir.

10.3 Biotic communities:-

a) **Plankton:-**The observations on the planktonic population and its abundance is presented in table 5. The average density of plankton population was 1449u/l. Bacillariophyceae dominated with 43.47% followed by Myxophyceae (34.45%) and Rotifers (12.39%). Pre-monsoon season was rich in plankton population with 1895u/l with least in winter (1138u/l). Zooplankton was constituted by Rotifers and copepods(Fig.39). The dominant forms of plankton were *Synedra,Tabellaria,Cyclops, Brachionus,, Cymbella, Spirulina, Spirogyra, Meridion Pediastrun, Frustulia, Anabeana, Scenedesums, Diatoma, Merismopedia, Mycrocystis and Oscillatoria. The* occurance of *Oscillatoria, Microcystis and Pediastrum* indicated the eutrophic tendency of the ecosystem.

b) **Periphyton -** The observations on the periphytic communities of Harsora reservoir is presented in table 6. Average periphytic communities observed were 910 u/cm^2 with Bascillariophyceae (79.98%) followed by Chlorophyceae (12.60%) and myxophyceae (7.41%). Pre-monsoon season was richest with 1050 u/cm^2. In post-monsoon periphytic population was 910 u/cm^2 and winter 770 u/cm^2 (Fig. 40).. The dominant periphyton observed are *Cymbella, Ulothrix, Synedra, Chladophora, Characium, Fragellaria, Microcystis, Meridion, Scenedesums* Gyrosigma *Navicula, Nitzschia and Cymbella.*

c) **Macrobanthos -** The observations on the benthic organisms of Harsora reservoir is presented in table 7. Harsora reservoir was very poor in benthos with average population of 391 orgs/m^2. Chironomids invariably dominant with 266 orgs/m^2 (68.03%). Annelids were absent in Harsora reservoir. Chaoborus larvae were next in dominance with 83 orgs/m^2 followed by Molluscs (42 orgs/m^2). Molluscs were invariably shells.

d) **Macrovegetation -** No vegetation or macrophytes have been observed from Harsora reservoir during pre-monsoon and post-monsoon season. However, very less vegetation of Hydrilla was observed in winter season, which was of no consequence.

10.4 Catch Statistics:-

Harsora reservoir has been auctioned by the Rajasthan fisheries to the highest bidder for a period of three years with some fixed increase from year to year basis. Contractors are responsible for stocking rearing and fishing operation under the supervision of Rajasthan fishery Deptt. The fishing is done by specialized fishing parties hired for the purpose by the contractors. No regular fishing is done through out the year.

The fish catch statistics data of the reservoir is not available as it has been reported that no production has been recorded from Harsora reservoir for past 3 years. However, stocking has been a regular feature from 2001-02 to 2005-06 with exception of 2002-03 when there was no stocking. Stocking in the range of 0.95 lakh-4.12 lakh has been done. But there is no record of species composition and size of stocking material (Table 16).

Fig. 37 A view of Harsora Reservoir

Fig. 38 Another view of Harsora Reservoir

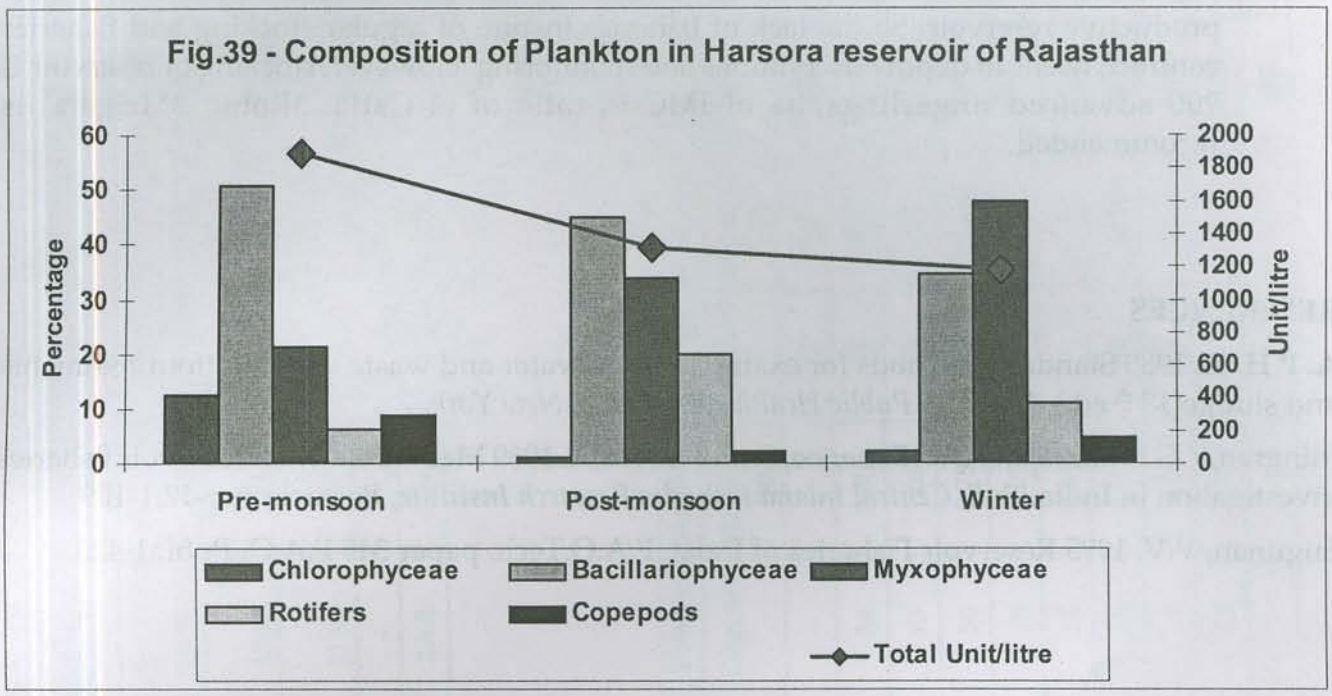
Fig.39 - Composition of Plankton in Harsora reservoir of Rajasthan
Percentage
60
50
40
30
20
10
0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Unit/litre
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Rotifers
Copepods
Total Unit/litre

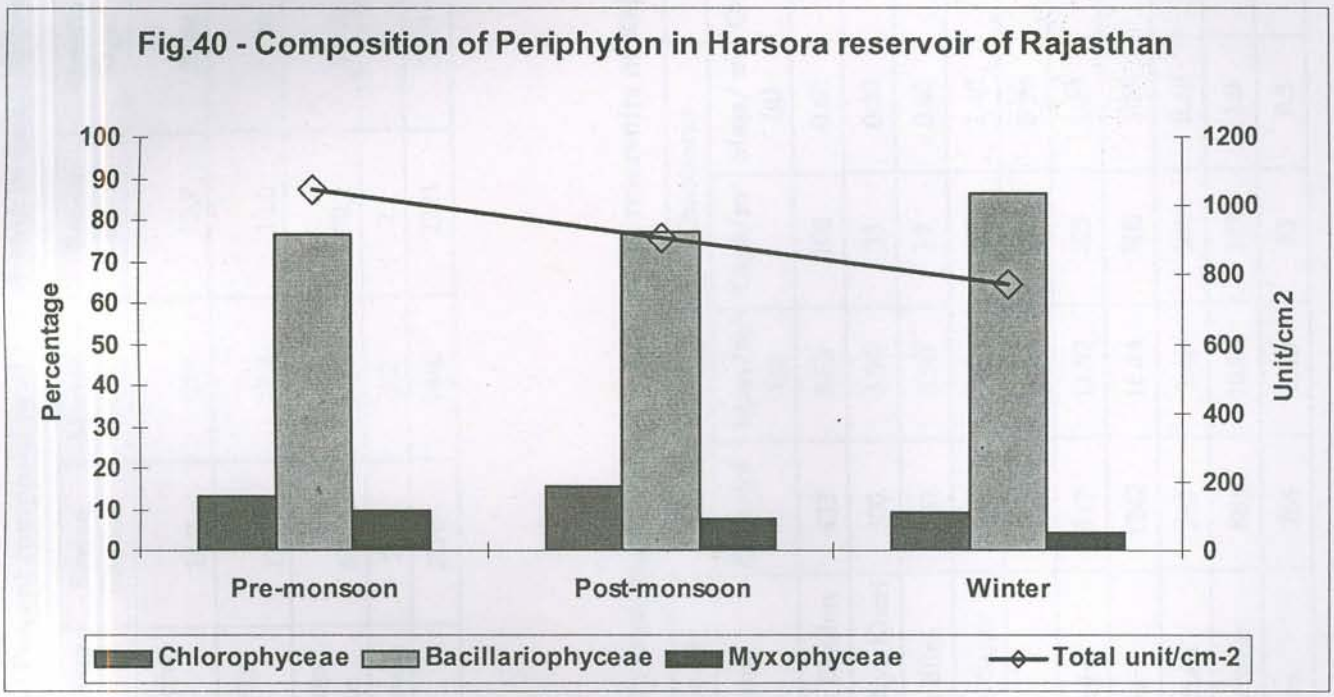
Fig.40 - Composition of Periphyton in Harsora reservoir of Rajasthan
Percentage
100
90
80
70
60
50
40
30
20
10
0
1200
1000
800
600
400
200
0
Unit/cm2
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Bacillariophyceae
Myxophyceae
Total unit/cm-2

10.5 Production status:- The production potential of Harsora reservoir is estimated at 119.0 kg/ha. As there is no record of fish from the reservoir. So it is not known the percent production of reservoir. The investigations shows that the reservoir is a moderate productive reservoir. So the lack of fisheries inspite of regular stocking and fisheries contract, needs in depth observations and monitoring. However, stocking of reservoir @ 900 advanced fingerlings/ha of IMC in ratio of (4 Catla: 3Rohu: 3Mrigala) is recommended.

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Table 1 : Salient features of small reservoirs of Rajasthan.

Parameters Location	Sawan Bhadon	Mundliya Kheri	Bandh Bilas	Urmila Sagar	Jagar	Ramsagar	Needer	Mamchari	Mansarovar	Harsora
Latitude N	24°50′	24°32′	25°20′	26°46′	26°45′	26°35′	26°18′	27°15′	27°14′	27°48′
Longitude E	76°07′	76°10′	76°49′	77°45′	77°70′	77°35′	77°11′	76°55′	76°26′	76°28′
District	Kota	Jhalawar	Baran	Dholpur	Karoli	Dholpur	Karoli	Karoli	Alwar	Alwar
Year of impound-ment	1991-92	State time	1996	1905	1957	1905	1956	1963	-	-
Area (ha) at FRL (A)	412.5	750.0	610.0	500.0	936.87	722.0	800.0	400.0	800.0	400.0
Av. (60%) area (ha)	247.0	450.0	366.0	300.0	562.12	434.0	480.0	240.0	480.0	240.0
Catchment area ($km^{2)}$	146.0	52.4	233.0	77.7	227.82	176.11	46.62	30.61	36.0	31.0
Catchment reservoir area (C/A)	35.4	7.0	38.2	15.54	24.32	24.39	5.82	7.65	4.5	7.75
Mean depth (m)	7.3	0.6	4.7	3.2	4.3	5.0	5.0	4.0	5.0	4.0
Gross storage capacity (Million m^3)	30.0	4.41	28.88	16.22	31.51	-	28.12	15.68	30.6	27.99
Average rainfall (mm)	-	510.8	291.0	640.0	400.0	518.83	675.0	675.0	-	-
River	Aru	Chander Bhaga	Bilas	Babudhan (Parvati)	Jagar (Gambiri)	Jangi/ Brahmani	Needer	Nami	Banganga	Shabi

Table 2 : Average Physico-chemical characteristics of soil of small reservoirs of Rajasthan.

Parameters	Sawan Bhadon	Mundliya Kheri	Bandh Bilas	Urmila Sagar	Jagar	Ramsagar	Needer	Mamchari	Mansarovar	Harsora
Sand (%)	40.8	26.3	20.9	58.65	65.02	64.6	54.73	54.13	52.4	52.55
Silt (%)	44.1	31.7	12.4	28.7	24.12	24.45	32.35	32.83	30.3	32.70
Clay (%)	15.1	42.0	66.7	12.7	10.85	10.95	12.93	15.53	17.3	14.82
pH	6.5	7.5	7.12	7.5	7.75	7.64	7.94	7.75	7.15	7.03
Organic carbon (%)	069	0.75	0.52	0.35	0.29	0.28	0.43	0.26	0.61	0.39
Free calcium carbonate (%)	1.63	1.88	1.75	23.51	23.02	14.43	23.5	17.85	17.1	16.94
Avl. phosphorus (mg/100g)	2.4	4.4	1.7	2.6	3.12	2.98	4.0	2.72	3.13	2.95
Avl. nitrogen (mg/100g)	8.54	7.28	8.68	9.35	9.87	10.91	14.72	12.5	23.43	19.67
El. conductance (Mmhos/cm)	259.0	512.0	224.0	247.0	292.5	252.5	265.5	255.5	224.5	272.5

Table 3 : Average Physico-chemical characteristics of water of small reservoirs of Rajasthan.

Parameters	Sawan Bhadon	Mundliya Kheri	Bandh Bilas	Urmila Sagar	Jagar	Ramsagar	Needer	Mamchari	Mansarovar	Harsora
Water temp. (°C)	25.7 (18.0-31.0)	26 (19-30)	27.2 (21.5-31)	25.34 (18-31)	26.56 (18-31)	26.86 (20.7-30.17)	25.79 (20.4-28.6)	25.23 (18.7-29)	25.7 (21.5-31)	24.17 (20-30.5)
Transparency (cm)	81 (35-125)	75 (15-122)	62 (57-69)	66.67 (30-125)	66.67 (20-120)	137.66 (43-235)	75.5 (42.5-109)	134.17 (75-245)	81.3 (22.5-133)	23.0 (11-32.5)
pH	7.7 (7.4-8.0)	8.2 (7.6-8.5)	8.0 (7.8-8.2)	7.67 (7.4-7.9)	7.82 (7.7-7.9)	7.63 (7.6-8.15)	8.05 (7.6-8.31)	7.99 (7.83-8.15)	7.25 (7.15-7.4)	6.9 (6.8-7.0)
DO (mg l^{-1})	8.7 (8.4-9.2)	8.9 (7.6-9.6)	9.0 (8.4-9.4)	9.54 (8.8-10)	9.14 (8.4-9.6)	7.63 (7-8.28)	8.34 (8.06-8.7)	8.5 (7.95-9.3)	8.1 (6.7-9.3)	8.03 (6.3-9.2)
Free CO_2 (mg l^{-1})	11.1 (1.2-22.0)	Nil	6.7 (2.0-10.0)	8.67 (4-14)	7.0 (2.0-10.0)	4.9 (3.7-7.0)	8.22 (6.0-12.0)	6.63 (6.4-7.0)	6.0 (nil-10)	4.67 (nil-8.0)
Total alkalinity (mg l^{-1})	139 (124-156)	99 (90-112)	111.0 (104-122)	121.0 (104-144)	116.34 (110-126)	86.27 (81.3-94.5)	131.83 (121-140.6)	86.63 (82-89.7)	69.60 (64.3-74.6)	79.17 (69.5-89)
Sp. conduct. (Mmhos/cm)	142 (118-168)	262 (150.6-412)	167.0 (130-240)	294.0 (256-356)	318.33 (264-394)	236.67 (223.5-256.7)	357.60 (342-359.8)	215.01 (208.5-222)	156.10 (138.3-180.7)	145.92 (129-154.7)
TDS (mg l^{-1})	71. (58.9-82.0)	130.5 (75-205)	84.7 (64-123)	149.5 (127-178)	160.1 (132-196)	118.3 (105-134)	78.8 (171-179.9)	107.5 (104.2-110)	128.5 (69-40.3)	72.95 (65-77.3)
Hardness (mg l^{-1})	101 (94-105)	103.0 (86-130)	110.0 (90-145)	114.6 (108-128)	123.0 (112-150)	Not observed	Not observed	Not observed	Not observed	Not observed
Calcium (mg l^{-1})	22.7 (20-24)	22.3 (19-26)	22.3 (18-30)	22.7 (20.6-24.6)	27.5 (24-34)	30.78 (28-36)	37.78 (36.2-40.7)	31.8 (27.4-35)	25.8 (20-35.7)	26.17 (25.5-27.5)
Magnesium (mg l^{-1})	11.5 (10.8-12.2)	11.1 (8.6-15.6)	12.9 (10.2-16.8)	16.10 (14.8-16.8)	13.0 (12-15)	16.33 (14-17.8)	17.12 (16.1-18.3)	15.4 (13.7-17)	15.8 (14-18.3)	18.3 (16.9-20)
DOM (mg l^{-1})	0.96 (0.79-1.1)	0.84 (0.62-1.05)	0.85 (0.80-0.92)	1.33 (1.12-1.68)	1.26 (1.12-1.52)	1.39 (1.18-1.49)	1.5 (1.39-1.6)	1.33 (1.22-1.42)	1.24 (1.06-1.47)	0.88 (0.64-1.15)
Phosphate (mg l^{-1})	0.28 (0.22-0.32)	0.25 (0.20-0.30)	0.28 (0.24-0.30)	0.10 (0.08-0.12)	0.19 (0.16-0.22)	0.32 (0.30-0.34)	0.37 (0.34-0.42)	0.35 (0.33-0.38)	0.26 (0.21-0.30)	0.22 (0.18-0.25)
Silicate (mg l^{-1})	0.65 (0.50-0.85)	0.88 (.40-1.60)	0.97 (.80-1.20)	0.88 (0.80-1.0)	0.81 (.76-0.90)	0.99 (.99-1.03)	1.05 (0.97-1.20)	1.24 (1.10-1.45)	1.10 (0.89-1.30)	1.05 (0.83-1.3)
Chloride (mg l^{-1})	9.50 (8.5-11.0)	33.0 (26-43)	24.3 (13-34)	8.34 (8-.0-9.0)	9.09 (8-10)	9.83 (9.34-10.75)	11.14 (10.17-12.25)	11.08 (9.75-12.5)	11.73 (9.8-13.83)	13.08 (11.5-15.7)

(Figures in brackets are ranges)

Table 4 : Average Primary production (mgC/m³/day) in small reservoirs of Rajasthan.

Parameters	Sawan Bhadon	Mundliya Kheri	Bandh Bilas	Urmila Sagar	Jagar	Ramsagar	Needer	Mamchari	Mansarovar	Harsora
Gross production	1262.52	887.64	958.32	1042.44	1354.08	1312.44	942.24	1666.68	617.24	586.12
Net production	737.52	500.04	483.36	645.6	750.0	733.32	562.44	1016.64	379.28	348.82
Respiration	649.92	465.0	519.96	518.4	750.0	628.32	471.0	680.52	232.56	235.86

Table 5 : Percent composition of plankton in small reservoirs of Rajasthan.

Parameters	Sawan Bhadon	Mundliya Kheri	Bandh Bilas	Urmila Sagar	Jagar	Ramsagar	Needer	Mamchari	Mansarovar	Harsora
Chlorophyceae	31.6	54.4	25.1	13.61	13.76	14.29	36.08	17.01	12.94	5.28
Myxophyceae	33.6	10.4	22.6	20.65	6.23	36.09	35.02	31.40	29.97	34.45
Bacillariophyceae	2.7	7.8	19.5	35.98	22.51	31.99	15.92	41.98	46.94	43.47
Dinophyceae	19.7	0.5	5.2	5.82	8.71	Nil	-	-	-	-
Rotifers	7.7	20.2	16.5	10.35	15.61	14.0	12.98	9.40	6.61	12.39
Copepods	4.7	6.7	11.1	13.58	32.89	3.63	-	0.21	3.99	4.41
Misc.	-	-	-	-	-	-	-	-	-	-
Unit/litre	3833	4611	1398	2443	1007	1609	1312	1797	881	1449

Table 6 : Percent composition of Periphyton in small reservoirs of Rajasthan.

Parameters	Sawan Bhadon	Mundliya Kheri	Bandh Bilas	Urmila Sagar	Jagar	Ramsagar	Needer	Mamchari	Mansarovar	Harsora
Chlorophyceae	14.7	10.9	15.7	39.84	18.03	29.04	33.14	38.46	23.23	12.60
Myxophyceae	13.6	17.4	12.0	19.30	21.10	18.99	22.03	10.81	70.27	79.98
Bacillariophyceae	69.4	69.5	70.2	40.85	69.86	51.97	44.83	50.73	6.50	7.41
Protozoans	2.3	2.2	2.1	-	-	-	-	-	-	-
u/cm²	2170	1860	2221	3739	4241	2263	2497	3637	1622	910

Table 7 : Distribution of benthos in small reservoirs of Rajasthan.

Parameters	Chironomids		Chaoborus		Molluscs		Tubificids/Anilids		Mosquito larvae		Total	
Reservoirs	Orgs/m²	Mass/m² (g)	Orgs/m²	Mass/ m² (g)	Orgs/m²	Mass/ m² (g)	Orgs/m²	Mass/ m² (g)	Orgs/m²	Mass/ m² (g)	Orgs/m²	Mass/m² (g)
Sawan Bhadon	433	5.63	100	0.60	67	Neg.	-	-	100	0.67	**700**	**6.90**
Mundliya Kheri	300	3.90	33	0.20	350	Neg.	34	0.50	33	0.33	**750**	**4.94**
Bandh Bilas	300	3.90	67	0.40	67	Neg.	83	1.08	50	0.50	**567**	**5.88**
Urmila Sagar	2100	27.30	100	1.40	317	Neg.	50	0.75	50	0.50	**2617**	**29.95**
Jagar	700	9.10	150	0.90	117	Neg.	16	0.05	-	-	**983**	**10.05**
Ramsagar	917	11.92	225	1.35	84	Neg.	25	0.38	-	-	**1251**	**13.65**
Needer	1242	16.14	300	1.80	100	Neg.	108	1.63	33	0.33	**1783**	**19.90**
Mamchari	283	3.68	100	0.60	83	Neg.	17	0.25	-	-	**483**	**4.53**
Mansarovar	883	10.94	183	1.0	33	Neg.	67	0.75	-	-	**1166**	**12.69**
Harsora	266	3.45	83	0.5	42	Neg.	-	-	-	-	**391**	**3.95**

Molluscs invariably were Shells

Table 3.1 : Depth Profile of various parameters of Sawan Bhadon reservoir.

Depth (m)	Water Temp. (°C)			pH			D.O. (ppm)			Free CO_2 (ppm)			Total alkalinity (ppm)			Sp. cond. (mmhos/cm)		
	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter
S	28.0	31.0	18.0	8.0	7.75	7.42	8.6	9.2	8.4	1.2	10.0	22.0	156	136	124	168	140	118
2	28.0	31.0	18.0	8.1	7.70	7.50	8.2	9.0	8.4	1.6	10.0	22.0	165	136	128	158	142	119
4	27.5	31.0	18.0	9.1	7.70	7.56	8.0	8.8	8.0	2.0	12.0	22.0	172	144	128	180	145	124
6	-	31.0	17.0	-	7.80	7.60	-	8.6	8.0	-	12.0	24.0	-	148	132	-	150	132
8	-	30.5	17.0	-	7.8	7.60	-	8.2	7.6	-	16.0	24.0	-	150	132	-	152	136
10	-	30.0	17.0	-	7.86	7.65	-	8.2	7.6	-	16.0	26.0	-	152	140	-	152	147

Table 3.2 : Depth Profile of various parameters of Mundliya Kheri reservoir.

S	29.0	30.0	19.0	7.60	8.4	8.5	7.6	9.6	9.6	Nil	Nil	Nil	94	112	90	412	223	250
1	29.0	30.0	19.0	7.66	8.3	8.4	7.6	9.2	9.2	Nil	Nil	Nil	102	115	90	404	227	256
2	29.0	30.0	19.0	7.70	8.3	8.4	7.6	9.0	9.2	Nil	Nil	Nil	106	115	90	400	230	256

Table 3.3 : Depth Profile of various parameters of Bundh Bilas reservoir.

S	31	29	21.5	8.0	8.0	8.0	8.4	9.4	9.2	2.0	8.0	10.0	122	104	106	240	130	130
2	31	29	21.5	7.82	8.06	8.0	8.2	9.4	9.2	2.0	8.0	10.0	133	110	110	244	134	132
4	31	28	21.0	824	8.12	7.8	8.2	8.0	8.8	2.0	10.0	15.0	142	112	110	246	140	128
6	-	28	-	-	8.10	-	-	8.0	-	-	10.0	-	-	110	-	-	140	-

Table 3.4 : Depth Profile of various parameters of Urmila Sagar reservoir

S	31.5	26	19	7.4	7.7	7.7	10.0	9.2	9.6	14	8	4	105	116	144	352	266	256
2	3.15	26	19	7.4	7.7	7.7	9.8	8.8	9.2	14	8	6	104	114	148	351	262	264
4	31.0	26	19	7.4	7.6	7.7	9.6	8.8	9.2	16	10	6	106	114	152	349	268	
6	-	26	-	-	7.6	-	-	8.4	-	-	10	-	-	112	-	-	260	-

Table 3.5 : Depth Profile of various parameters of Jagar reservoirr

Depth (m)	Water Temp. (°C)			pH			D.O. (ppm)			Free CO_2 (ppm)			Total alkalinity (ppm)			Sp. cond. (mmhos/cm)		
	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter
S	30	30	18.5	7.9	7.7	7.8	9.6	8.6	9.2	10	8.0	2.0	120	112	115	392	295	272
2	30	30	18.5	7.9	7.7	78	9.2	8.4	9.0	8	8.0	4.0	122	110	114	391	296	274
4	30	30	18.5	7.8	7.7	7.8	8.8	8.4	8.8	8	8.0	8.0	124	106	110	395	297	276
6	-	30	18.5	-	7.7	7.8	-	8.2	8.8	-	8.0	8.0	-	106	108	-	299	278
8	-	30	18.5	-	7.6	7.7	-	8.0	8.6	-	8.0	8.0	-	102	108	-	300	280

Table 3.6 : Depth Profile of various parameters of Ramsagar reservoir.

S	31	28	21	8.15	7.7	7.6	7.2	8.0	8.4	2.0	6.0	4.0	90	96	80	223	231	250
2	31	28	21	8.15	7.7	7.6	7.0	8.0	8.4	4.0	6.0	4.0	82	96	80	228	233	250
4	30	28	21	8.2	7.7	7.6	7.0	7.6	8.4	4.0	8.0	4.0	86	98	80	232	235	256
6	-	27	20.5	-	7.8	7.6	-	7.6	8.2	-	8.0	4.0	-	98	82	-	235	260
8	-	-	20.0	-	-	7.7	-	-	8.0	-	-	4.0	-	-	84	-	-	262

Table 3.7 : Depth Profile of various parameters of Needer reservoir.

S	29	28	20	8.3	8.0	7.6	8.2	8.6	8.8	6.0	10	6.0	144	119	133	360	353	357
2	29	28	20	8.2	8.0	7.6	8.2	8.6	8.8	6.0	10	6.0	140	120	133	357	354	359
4	28	28	20	8.3	8.0	7.6	7.8	8.2	8.6	6.0	12	6.0	138	122	135	362	355	360
6	-	27	19.5	-	8.1	7.6	-	8.2	8.6	-	12	6.0	-	123	134	-	355	359

Table 3.8 : Depth Profile of various parameters of Mamchari reservoir.

Depth (m)	Water Temp. (°C)			pH			D.O. (ppm)			Free CO_2 (ppm)			Total alkalinity (ppm)			Sp. cond. (mmhos/cm)		
	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-monsoon	Winter	Sum.	Post-mon-	Winter
S	28	29	19	8.25	8.0	7.8	8.2	8.4	9.6	7.0	6.0	6.0	82	89	87	206	217	211
2	28	29	19	8.25	8.0	7.8	7.8	8.2	9.4	7.0	6.0	6.0	82	89	87	211	221	214
4	-	29	19	-	8.0	7.8	-	8.0	9.2	-	6.0	6.0	-	90	87	-	221	214
6	-	29	18	-	8.1	7.9	-	8.0	9.0	-	6.0	6.0	-	90	88	-	220	216
8	-	29	18	-	8.1	7.9	-	8.0	9.0	-	6.0	6.0	-	90	88	-	220	217

Table 3.9 : Depth Profile of various parameters of Mansarovar reservoir.

S	31	24.5	21.5	7.2	7.25	7.35	6.36	8.4	9.6	8.0	10.0	Nil	63	76	69	181	137.5	149
2	31	24.5	21.5	7.2	7.20	7.40	6.6	8.4	9.2	8.0	10.0	Nil	64	76	70	181	138	149.5
4	31	24.5	21.5	7.1	7..20	7.4	6.6	8.2	9.2	8.0	10.0	Nil	66	74	70	180	139	150
6	30	24.5	-	7.1	7.20	-	6.6	8.2	-	8.0	10.0	-	66	72	-	180	139	-

Table 3.10 : Depth Profile of various parameters of Harsora reservoir.

S	31	23	20	6.8	7.05	6.8	6.3	8.8	9.4	6.0	8.0	Nil	79	70	90	153	128	154
1	31	22	20	6.8	6.9	6.9	6.3	8.4	9.2	6.0	8.0	Nil	80	69	88	155	130	155.5
2	30.5	22	20	6.9	6.9	6.9	6.3	8.4	9.0	6.0	8.0	Nil	80	70	88	154	130	155

Table 8 : Distribution of macrovegetation (kg/m²) in small reservoirs of Rajasthan.

Reservoirs	Pre-monsoon		Post-monsoon		Winter		Average	
	Wet wt.	Dry wt.	Wet wt.	Dry wt.	Wet wt.	Dry wt.	Wet wt.	Dry wt.
Sawan Bhadon	-	-	-	-	-	-	-	-
Mundliya Kheri	0.480	0.090	0.230	0.075	0.565	0.115	0.455	0.093
Bundh Bilas	-	-	-	-	-	-	-	-
Urmila Sagar	3.50	0.120	1.750	0.075	3.000	0.150	2.750	0.115
Jagar	4.300	0.150	2.500	0.075	-	-	2.266	0.075
Ramsagar	3.500	0.125	1.250	0.200	1.750	0.300	2.166	0.208
Needer	2.250	0.070	2.500	0.175	2.300	0.200	2.350	0.150
Mamchari	2.100	0.080	2.200	0.100	2.40	0.175	2.233	0.358
Monsarovar	3.300	0.110	3.900	0.140	4.200	0.458	3.800	0.236
Harsora	-	-	-	-	-	-	-	-

Table 9 : Catch composition (t) during 2001-02 in reservoirs of Rajasthan.

Groups/Reservoir	Sawan Bhadon	Mundliya Kheri	Bundh Bilas
IMC	15.48	1.58	16.80
Cat fishes	4.63	0.22	2.48
Minor carps	9.39	1.76	5.05
Misc.	-	-	5.31
Total	29.5	3.56	29.64
Kg/ha	119.0	8.0	81.0

Table 10 : Catch composition (t) during April,02-Jan., 2003 in reservoirs of Rajasthan.

Groups/Reservoir	Sawan Bhadon	Mundliya Kheri	Bundh Bilas
IMC	9.55	9.51	16.06
Cat fishes	-	2.04	1.79
Minor carps	13.40	1.36	4.99
Misc.	6.22	0.68	7.34
Total	29.17	13.59	30.17
Kg/ha	118.0	30.0	82.0

Table 11 : Stocking (fry in lakhs) in reservoirs of Rajasthan.

Reservoirs/Years	1998-99	1999-2000	2000-01	2001-02	2002-03	Average/ha
Sawan Bhadon	-	17.5	17.5	34.0	1.93	0.344
Mundlia Kheri	-	-	-	2.1	3.70	0.0015
Bundh Bilas	10.0	4.67	0.49	15.0	3.75	0.0111

Table 12 : Catch composition of fish from small reservoirs of Rajasthan.

Reservoir	Urmila Sagar				Jaggar Reservoir			
Year/Variety	IMC	Minor carps	Others	Total	IMC	Minor carps	Others	Total
1999-2000	-	-	-	-	42.42	8.87	23.81	75.11
2000-01	-	-	-	-	21.40	3.99	7.21	32.60
2001-02	5.0	2.5	2.5	10.0	11.20	0.70	1.00	12.91
2002-03	10.0	5.0	5.0	20.0	57.25	12.10	15.5	84.85
2003-04	14.0	5.0	3.0	22.0	15.17	6.81	3.05	25.03

Table 13 : Stocking of Indian Major Carps (in lakhs) in reservoirs of Rajasthan.

Year/Reservoirs	Urmila Sagar	Jaggar Reservoir
1999-2000	-	10.0
2000-01	-	11.0
2001-02	10.0	10.0
2002-03	-	9.25
2003-04	9.8	19.20

All Indian Major Carps.

Table 14 : Stocking of Indian Major Carps (in lakhs) in small reservoirs of Rajasthan.

Reservoirs/Year	2003-04	2004-05
Ramsagar	-	5.0
Needar	18.5	14.5
Mamchari	16.5	0.27

Table 15 : Fish production from small reservoirs of Rajasthan.

Reservoirs/ Year	2003-04		2004-05		Auction amount (in lakhs)
	Kg	Kg/ha	Kg	Kg/ha	
Ramsagar	65900	91.27	-	-	6.63
Needar	14256	17.82	46000	57.50	5.54
Mamchari	18256	45.64	55500	138.75	1.95

Table 16 : Stocking of Indian Major Carps(in lakhs) in small reservoirs of Rajasthan.

Reservoirs/Year	2001-02	2002-03	2003-04	2004-05	2005-06
Mansarovar	17.0	6.0	4.0	5.0	4.0
Harsora	3.30	-	4.10	4.12	0.95

Table 17 : Fish production of Mansarovar reservoirs of Rajasthan.

Reservoirs/Year	2001-02	2002-03	2003-04	2004-05	2005-06
IMC	4.9	7.1	27.1	16.6	-
Minor carps	1.3	2.6	1.4	3.9	-
Cat fish	0.5	1.2	1.5	2.5	-
Others	-	0.7	4.5	2.2	-
Total (mt)	6.7	11.60	34.5	25.21	9.25

Hasora:- Production has not been reported from the reservoir.