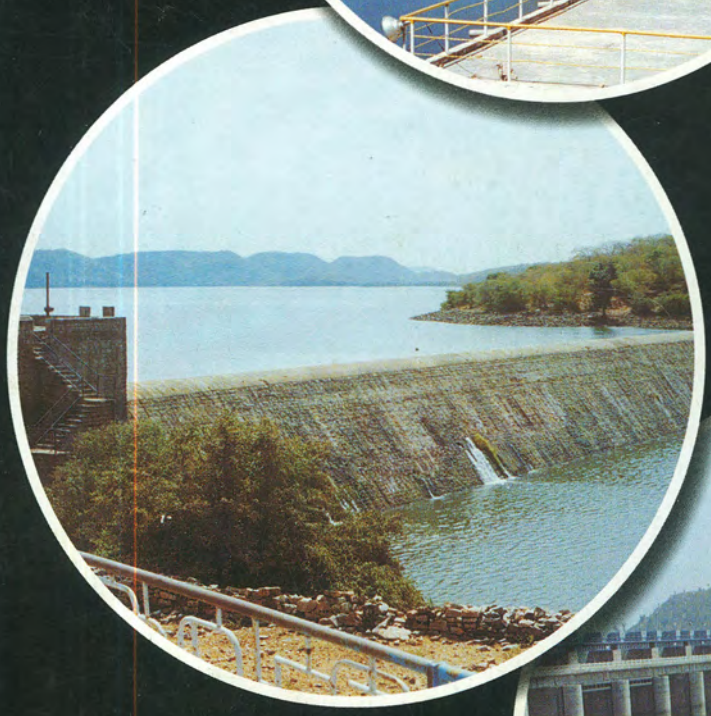
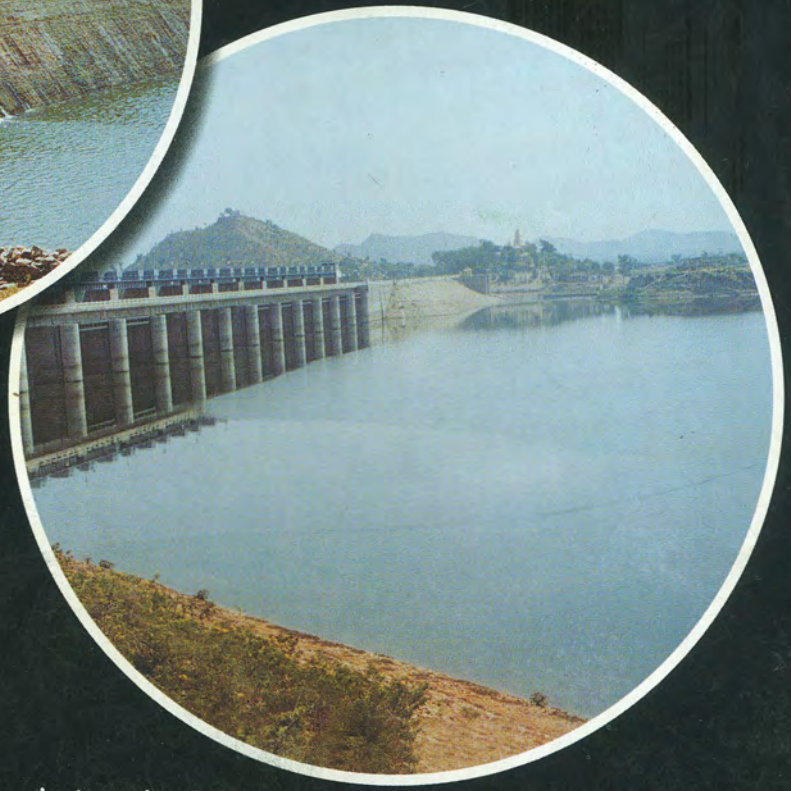
Ecology and Fisheries of Selected Reservoirs of Southern Rajasthan





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ECOLOGY AND FISHERIES OF SELECTED RESERVOIRS OF SOUTHERN RAJASTHAN

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FORWORD

Reservoir or man-made lakes has a special role to play in the development of the Country's inland fish production. The development of reservoir fisheries has greater relevance in developing Countries like India as it has tremendous scope for yield enhancement besides more labour incentive and eco-friendly in nature. Keeping this aspect in view CICFRI initiated investigations on the ecology and fisheries of reservoirs situated in different states of India. As pert of this study, scientists of CICFRI surveyed reservoirs of South-eastern Rajasthan during the years 2000-01 and 2001-02 and this publication is a documentation of the research data generated during the investigations. I am hopeful that this document will greatly help in formulating guidelines for scientific management not for the said reservoirs alone but for other similar water bodies available in the region.

I hope on record the valuable co-operation received from the Department of Fisheries, Rajasthan during the investigation. Their unflincing support has helped us to achieve our goal.

D. Nath
Director
CIFRI

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CONTENTS

INTRODUCTION

India is endowed with vast inland fishery resources of which reservoirs are of prime importance having a great potential to enhance the Country's inland fish production several fold. The state of Rajasthan located in the Western part of the country between latitudes 23°-41' to 30°-11'N and longitude 69°-29' to 78°-16'E shows noticeable disparity in the water resources, climate, soil and vegetation etc. Rajasthan encompassing an area of 342239 km^2 has 3.3 lakh hectares of water area under fish culture of which 1.2 lakh ha comes under large and medium reservoirs while 1.8 lakh ha of water fall under small reservoirs and ponds. The eastern region of Rajasthan is extensively drained by the river Banas and its many tributaries. This region has a large number of reservoirs especially in the districts of Dausa, Tonk, Swai Madhopur, Bundi, Alwar and Bharatpur. The sprawling Western region is arid and virtually a desert land wherein no reservoir exist. A large number of small impoundments have of Pali, Udaipur and Sirohi. The southern region of the state consisting the districts of Banswara, Chittorgarh, Rajsamand, Jhalawara and Kota has a maximum number of man-made lakes. The four large reservoirs viz. Rana Pratapsagar (19600 ha, Chittorgarh district), Mahi Bazazsagar (13500 ha, Banswara district), Kadana (900 ha, Banswara & Dungarpur districts) and Jaisamand (7600 ha, Udaipur district) covers more than 32% of the total reservoir area.

Management practices with proper stock manipulation by adopting a judicious exploitation-cum-stocking policy are the keys for hikes in productivity of a reservoir. Taking a clue from this concept the exploratory survey on selected reservoirs of Southern Rajasthan was conducted to understand the ecology and fish yield potential of the reservoirs during the years 2000-01 and 2001-02. This survey also envisaged a probe into the present status of fisheries development and management of different reservoirs to formulate management plans capable of enhancing fish productions of the reservoirs on scientific lines (Sugunan, 1995, Jhingran, 1986).

RESERVOIR SELECTED FOR STUDY

Nine reservoirs were selected from three river system for the purpose of present study. They are Khari, Kothari, Orai, Gambhiri, Udaisagar and Nandsamand from the Banas river system; Som Kamla Amba from the Mahi river system and West Banas and Jawai from the West Banas river system. Most of the reservoirs are designed for irrigation. Udaisagar is also used as a storage tank for supply of water to a nearby factory. Similarly, West Banas reservoir also serves as a water tank for supply of water to a cement factory.

SAMPLING PROCEDURE

Studies covering morphometric and hydrological characteristics, soil and water quality parameters, carbon production, abundance of fish food resources and fish catch statistics were made on season survey basis during pre-monsoon (May-June),post-monsoon (October-November) and winter (January-February)

in the year 2000-01 in respect of Khari, Kothari, Orai , Udaisagar and Som Kamla Amba and in the year 2001-02 in respect of Gambhiri, Nandsamand, West Banas and Jawai reservoir. The physico-chemical parameters were determined following the standard methods given in APHA, 1989. The collection and analyses of biological parameters were done as described by Jhingran *et al.*, 1969.

1. KHARI RESERVOIR

1.1 Morphometric and hydrological characteristics

Khari, an impoundment across the river Khari a tributary of the river Banas, is located at latitude 20°-42'N near the village Khari Dantra in Bhilwara district . It is a four decades old reservoir constructed for irrigation in the year 1956. The upper reaches of the reservoir surrounds by hills of Aravali range. It has a water spread area of 773 ha at FTL and a catchment area of 712 km^2. The low mean depth of 5.0 m indicate shallow character . The ratio of catchment/ area (considered to be an index of allochthonous inputs) is high (92) and indicates inputs of nutrients through the catchment. The atmospheric temperature varied from 20°C in winter to 35°C in post-monsoon. The average rainfall in the area is 630 mm (Table 1).

1.2 Limnology and productivity

Soil quality :- Basin soil was sandy loam in texture. Soil was alkaline in reaction (pH 7.27) and was deficient with regards to organic carbon (0.45%) and available nutrients (Table 2).

Water quality :- The water temperature was lowest in winter (15.5°C) while it was highest in post-monsoon (30°C). The alkaline (pH 7.5) water enable the normal ion exchange of fresh water fishes and is favourable for fish growth. Transparency varied from 44 in post-monsoon to 64 cm in winter (Table 3). Low wind turbulence in winter could have Resulted in high transparency. Dissolved oxygen was congenial with mean value of 7.7 mg/l. Free CO_2 was absent in all the seasons. The average total alkalinity (130.7 mg/l) was found conducive to high fish productivity. Higher ionic concentration (µmhos/cm) indicated eutrophic conditions.

Calcium concentration was found to be moderate (20-24 mg/l).Magnesium content varying between 13.2 and 15.0 mg/l was of high order. Total hardness reflected the trends of magnesium . The mean value of chloride was 9.2 mg/l. The concentration of phosphorus is poor to moderate (Table 3) considering 0.05 to 0.20 mg/l of phosphorus as favourable for productivity . It ranged from 0.006 to 0.08 mg/l. The concentration of silicates was moderate (1.8 mg/l). The nutrients are thus low concentration which may be due to quick turnover of these elements or their loading from catchment is of low order.

Depth-wise observations did not show presence of thermal stratification. Chemical parameters (Table 4.1) showed signs of weak chemical stratification.

Primary productivity

Observations on primary productivity showed an average gross production of 1375 mgC/m²/hr (Table 5). Energy assimilation efficiency (62.6%) was nearer to that of productive reservoir. The potential

1.3 Biotic communities

Plankton :- The plankton population ranged from 1600 u/l in post-monsoon to 6065 u/l in winter and had an annual average production of 3691 u/l. Myxophyceae formed 48.7% of the total plankton population (Fig. 2). The major pulse was observed during winter (85.5%). The common forms observed were *Microcystis, Anabaena, Oscillatoria, Phormidium* and *Cocchochloris*. Chlorophyceae constituted 22.0% of the total plankton and was mainly represented by *Spirogyra, Rhizoclonium, Scenedesmus, Oeologenium, Mougeotia, Zygnama, Crucigenia, Characium, Pediastrum, Chlorococcum, Ankistrodesmus, Characiopsis* and *Protococeus*. Maximum percentage of this group was in summer. The percentage composition of bacillariophyceae fluctuated from 4.3 in winter to 13.3 in post-monsoon. Zooplankton were mainly dominated by rotifers (*Keratella, Brachionus, Filinia, Notholea* and *Asplamchma*) constituting 7.2% of the total plankton . Copepods (*Cyclops, Diaptomus*) formed 6.6% of the total plankton (list of plankton presented in Table 6. Pollution indicator species such as *Anabaena, Phormidium* were rare indicating predominance of clean water species in ecosystem.

Periphyton :- Periphytic communities ranged between 1746 u/cm² in post-monsoon to 1940 u/cm² in winter and had an abundance of 1843 u/cm² (Fig. 3) . Bacillariophyceae (63.4%) dominated over chlorophyceae (19.1%) and myxophyceae (12.2%).

Macrobenthos :- The standing crop of macrofauna was estimated as 783 u/m² (Table 7). Chironomids constituted 61.6% of the total fauna followed by *Chaoborus* (19.2%) and molluscs (19.2%).

Macrophytes :- Aquatic weeds occurred in all the seasons varying from 0.40 kg/m² wet wt. in post-monsoon to 1.50 kg/m² wet wt. in winter. The dominant form were *Hydrilla, Vallisneria* and *Potamogeton* (Table 8).

1.4 Fisheries

Khari reservoir is being exploited through open auction system wherein the reservoir is leased out to a private contractor for a period of three years. The fishing is being conducted irregularly by fishing parties brought from other states. Gill-nets are the dominant gear followed by cast nets, drag nets and traps. As per the regulation of Rajasthan Fisheries rules the contractor is supposed to stock the reservoir @ 500 fingerlings/ha. However, the available records indicate erratic stocking of Indian major carps varying between 0.95 (1999-2k) and 20.00 lakh fry (1998-99) averaging 1356 fry/ha (Table 9).

Observation on the fish catch (1999-2k) revealed no fishing in the reservoir while a total of 11.99 t of fish landed in 2000-01. Thus, the fish yield was 25.8 kg/ha. The Indian major carps accounted for 59% of the total catch (Table 10). Cat fishes mainly *M. seenghala* and W. attu contributed 22% to the catch while minor carps represented by *L. gonius, L. bata, B. bola* and *P. sarana* formed 19% of the catch. The major carps thus were dominant in the catches.

1.5 Management Guidelines

The investigations has revealed that the reservoir is not managed scientifically. Stocking policy is confined to release of fry of Indian major carps without paying adequate attention to the biogenic capacity of the ecosystem. A sound management program based on the yield potential and availability of food resources is therefore needed. The scope for various management measures is illustrated below.

Khari is a small reservoir wherein major carps contributes substantially in the catch. Obviously it was impart of regular stocking at an average rate of 1356 fry/ha. Khari has a good population of plankton consisting of myxophyceae and chlorophyceae. A stocking program with emphasis on mrigal alongwith rohu and catla should be undertaken to realize the production potential (500 kg/ha). The stocking rate could be 900 fingerlings/ha of the size 50 mm. The stocking rate may be reduced if size of fingerlings is between 50-100 mm. Addition of common carp should be considered for stocking to exploit the bottom biota. Presently stocking of fish at fry stage could be one of the reason for low fish yield (25.8 kg/ha) inspite of the high production potential. Fish production can further be enhanced significantly by adopting

size gill-nets of size below 40 mm mesh bar which cause the mortality of fish at younger stage vis-à-vis reduces the autostocking . Gill-nets of mesh bar 40 to 60 mm may be used regularly instead of their seasonal use. Exploitation of reservoir under the aegis of co-operative society may be probed.

2. KOTHARI RESERVOIR

2.1 Morphometric and hydrology features

Kothari impoundment is situated at latitude 25°-18'N near Trivani Town. It lies across the river

in the year 1990. It has a water spread area of 785 ha at FRL and catchment area of 2176 km^2. It is a shallow reservoir having a mean depth of 3.3 m. The atmospheric temperature in the area ranged from 24.0 in winter to 38.0oC in post-monsoon. The total rainfall accounted to 69.0 cm (Table 1).

2.2 Limnology and productivity

Soil quality :- The basin soil was silty (silt 38.8%; Table 2) in texture and was alkaline in reaction (pH 7.65). The soil was deficient with regards to both organic carbon (0.43%) and available phosphorus

(0.24 mg/100g). The low phosphorus concentration in the soil could be due to rapid assimilation of available phosphorus in the biota. The basin soil, however, seems to have limited impact on the water quality as the late mainly derives the nutrients from the catchment area.

Water quality :- Barring summer months, the water of Kothari impoundment remains clear imparting a greenish tinge. Transparency fluctuated from 33 cm in summer to 197 cm in post-monsoon. Surface water temperature varied between 16.0 and 28.0°C .The water is alkaline (pH 7.6) which enable the normal ion-exchanges of fresh water fishes. Dissolved oxygen ranged between 5.6 and 8.0 mg/l. Free CO_2 appeared in post-monsoon (2.6 mg/l) and in winter (5.0 mg/l). Seasonal variation in total alkalinity was quite discernible with minimum values in post-monsoon (82.0 mg/l) and maximum in pre-monsoon (116.0 mg/l). The total alkalinity (102.7 mg/l) thus was conducive to high fish productivity.

Calcium concentration was moderate ranging between 24 and 32 mg/l. Magnesium content varied from 8.4 to 9.6 mg/l. Chloride values fluctuated between 5.0 to 8.3 mg/l. Dissolved organic matter varying between 3.2 and 6.0 mg/l indicated fairly productive state of the reservoir. Water was deficient with regards to phosphate (0.033 mg/l) and silicate (2.2 mg/l). Specific conductivity fluctuated from 177.0 to 438.0 µmhos/cm. High values of specific conductivity support productive character of the impoundment (Table 3).

Depth-wise observations in respect of water temperature did not show presence of thermal stratification. Chemical parameters (Table 4.2) exhibited weak chemical stratification.

Primary productivity :- The primary productivity studies revealed an average gross production of 1375 mgC/m^2/d while the average net production as 862 mgC/m^2/d (Table 5). Energy assimilation efficiency (60%) showed productive state of the water body. The expected fish yield in terms of carbon production is 350 kg/ha/A which shows the medium productive state of the reservoir.

2.3 Biotic Communities

Plankton :- The plankton population ranged from 1085 u/l in winter to 2202 u/l in pre-monsoon and had an annual average production of 1732 u/l (Fig. 2b). On an average, phytoplankton formed 75% of total plankton. Among phytoplankters, myxophyceae out numbered chlorophyceae and bacillariophyceae, forming 33.7% of the total plankton. The major pulse of myxophyceae was observed in post-monsoon (48.0%) whereas its minimum concentration (22.7%) was in pre-monsoon months. Blue-green algae was comprised of *Microcystis, Spirulina, Phormidium, Anabaena, Nostoc* and *Oscillatoria*. Chlorophyceae constituted 19.1% of the total plankton and was mainly represented by *Rhizoclonium, Scenedesmus, Botrycoccus, Characium, Oedogenium , Ulothrix, Pediastrum, Troschia* and *Cosmarium*. Diatoms formed 16.5% of the total plankton and were represented by *Meridion, Cyclotella, Navicula, Melosira, Synedra, Gyrosigma, Cymbella, Tabellaria, Cocconeis* and *Nitzschia.* Rotifera and copepoda formed the bulk of zooplankton. Rotifers (14.7%) were represented by *Keratella, Brachionus, Filinia, Notholca, Colurella, Asplanchia, Trichocerea* while copepods (7.2%) were represented by *Cyclops* and

Diaptomus. The significant occurrence of rotifers in Khari may be due enrichment of organic nutrients through influx of municipal effluents. *Arcella* was the common forms of Protozoa occurring in the reservoir. Occurrence of *Anabaena, Oscillatoria, Microcystis, Scenedesmus* and *Pediastrum* indicated eutrophic tendency of the reservoir (List of plankton is given in Table 6).

Periphyton :- Periphytic communities (1907 u/cm^2) were dominated by bacillariophyceae (69.4%; Fig. 3b). Diatoms were represented by *Synedra, Navicula, Cymbella, Tabellaria, Caloneis, Gyrosigma, Nitzschia, Melosira* and *Amphora*. Chlorophyceae (13.6%) was comprised of *Characium* and *Cladophora*. Protozoans were represented by *Difflugia*.

Macrobenthos :- The standing crop of bottom fauna was estimated as 983 u/m^2 (Table 7). Chironomids constituted 56% of the total fauna followed by tubificids (18.6%), molluscs (13.5%) and chaoborus (11.9%).

Macrovegetation :-The reservoir catchment in Kothari being agriculture land has got good level of nutrients due to which a variety of vegetation has been noticed. The macrophytes ranged from 0.72 kg/ m^2 in winter to 0.90 kg/m^2 in pre-monsoon an average of 0.54 kg/m2 wet wt (Table 8). The dominant forms were *Hydrilla, Vallisneria* and *Potamogeton. Marsilea* occurred rarely.

2.4 Fisheries

Fishing in the reservoir is irregular and is being conducted by fishing parties engaged by a contractor to whom the reservoir is leased out for a period of three years through an open auction. Available records (Table 9) on stocking exhibits that it varied from 0.80 (1996-97) to 18.00 (2000-01_ lakh fry averaging 1509 fry/ha/A.

Observations reveals that the fish yield (kg/ha) in Kothari has decreased from 45.2 in 1999-2k to 14.9 in 2k-01. Major carps dominated by *C. catla* formed 50% of the catch. Cat fishes (*M. seenghala, W. attu, N. notopterus*) constituted 32% of the catch. Other fishes in the catch were *C. reba, L. bata, L. gonius* and *Channa sp* (Table 10).

2.5 Management guidelines

Kothari is one of the recent impoundments whose catchment has been intercepted by dams in the upstream. It has a good population of fish food organisms. The limnological investigations revealed high productive potential (350 kg/ha) against which the annual yield in 2000-01 was 15.0 kg/ha. The exploitation efficiency is thus quite low (0.04%). The fish production can further be enhanced by adopting better management measures. The reservoir needs stocking support with emphasis on catla, rohu and mrigal to realize the potential. The fingerlings @ 650 number per hectare may be stocked. Gill-nets of mesh bar 40-60 mm may be used regularly. Exploitation of reservoir under the aegis of co-operative society may be probed. The pen and cage culture systems can be introduced in this reservoir to boost the fish yield.

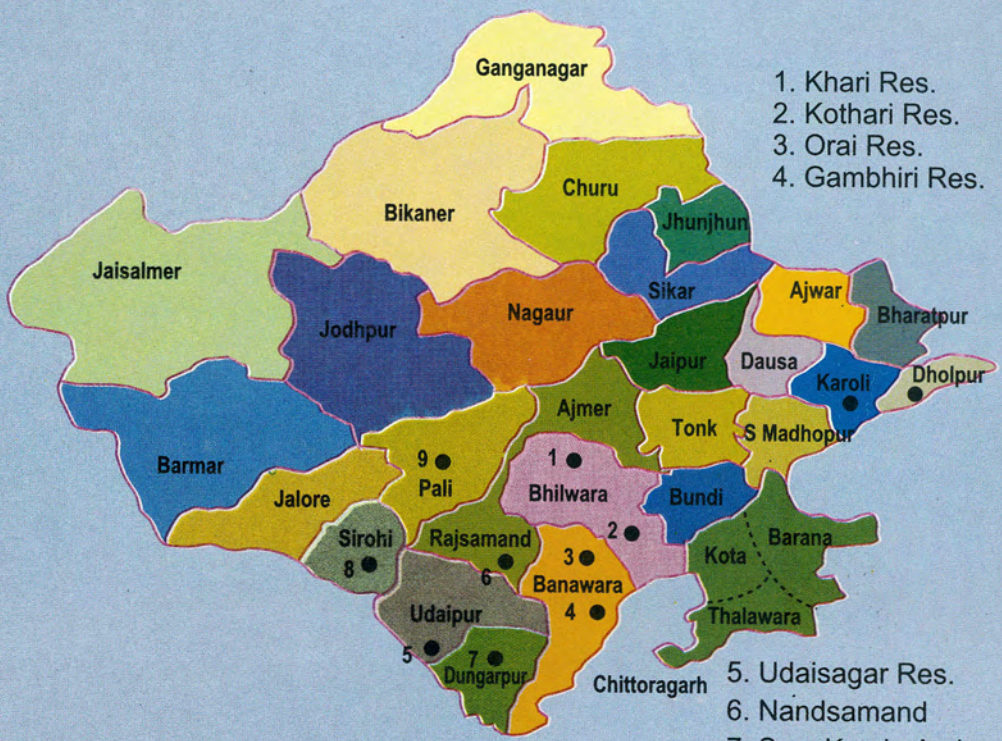

Fig. 1 Distribution of Reservoirs studied in Rajasthan

3. ORAI RESERVOIR

3.1 Morphometric and hydrology characteristics

Orai reservoir is situated around 35 km away from Chittorgarh town and is surrounded by hills of Aravali ranges. It was constructed by blocking the river Orai in the year 1972-73 mainly for irrigation. It lies in the Banas river system. The impoundment has a water spread area of 640 ha at FTL and a total catchment area of 220 km^2 (Table 1). The C/A of 34 indicate lesser inputs of allochthonous nutrients through the catchment. The mean depth (5.5 m) shows shallow nature of the water body. Atmospheric temperature varied from 20 in winter to 34°C in post-monsoon. The total rain fall in the area is around 600 mm.

3.2 Limnology and productivity

Soil quality :- Basin soil of the reservoir is sandy loam in texture sand (64.1%) and silt (30.5%). The soil was deficient with regards to available phosphorus (0.16 mg/100g) and nitrogen (10.5 mg/100g). The low phosphorus concentration in the soil reflects rapid assimilation of available phosphorus in the biota. The organic carbon was of moderate range (0.91%) (Table 2).

Water quality :- The water transparency fluctuated from 51 cm in pre-monsoon to 155 cm in post-monsoon. Low transparency in pre-monsoon may be attributed to shallowness of the reservoir coupled with high wind action. The water temperature varied from 16 in winter to 28°C in pre-monsoon. The alkaline water (pH 7.4) is favourable to fish growth. Dissolved oxygen ranged between 6.8 and 8.4 mg/l. Free CO_2 appeared in post-monsoon (3.6 mg/l). The seasonal variation in total alkalinity was quite discernible with minimum value in post-monsoon (86 mg/l) and maximum in pre-monsoon (108 mg/l). Assessment of the productivity based on total alkalinity (av. 95 mg/l) reflected the water body fairly productive.

Calcium content of water ranged between 25 and 36 (av. 30.3) mg/l. Magnesium concentration varied from 9.6 to 15.6 (av. 12.2 mg/l). Chloride value fluctuated from 3.3 to 9.0 mg/l. Dissolved organic matter ranged from 3.4 to 6.4 mg/l indicating fairly high content of dissolved matter vis-à-vis productive state of the reservoir. Water had low values of phosphate (0. 005 mg/l) and moderate silicate (2.0 mg/l). Specific conductivity fluctuated from 174 to 285 µmhos/cm and supported the productive character of the reservoir (Table 3).

Depth profile observations up to 8 m in respect of water temperature (Table 4.3) did not show presence of thermal stratification. The reservoir water had a maximum difference of 1°C from surface to bottom. The shallowness of the reservoir aids in free mixing which prevents the formation of thermocline. Chemical parameters like dissolved oxygen, total alkalinity and specific conductivity did not show signs of weak chemical stratification reflecting productive character of the water body.

Primary productivity :- Studies on primary productivity exhibited an average gross production of 1028 and net production of 639 mgC/m^2/d (Table 5). Energy assimilation efficiency (62.2%) was nearer to that of productive reservoir. The expected fish yield in terms of carbon production is 375 kg/ha which showed the high productive state of the reservoir.

3.3 Biotic communities

Plankton :- Observation on the plankton population revealed an average abundance of 2781 u/l (Fig. 2c). Chlorophyceae formed 52.1% of the total plankton and were mainly represented by *Rhizoclonium, Scenedesmus, Botryococcus, Mougeotia, Zygnema, Crucigenia, Protococcus, Characiopesis, Ankistrpdesmus, Cerastrias, Tetracdron, Chlorococcum, Pachycladom* and *Trochiscira*. Myxophyceae constituted 21.4% of plankton and were represented by *Microcystis, Oscillatoria, Nostoc, Spirulina* and *Cocchochloris*. Bacillariohphyceae represented by *Meridion, Rhoicosphenia, Navicula, Frustulia, Synedra, Diatoma, Achnamthes, Amphiplenra, Tabellaria* and *Cocconeis* formed 6.4% of the total plankton Among zooplankton, rotifers (*Keratella, Polyarthra, Brachionus, Filinia, Notholoca, Trichocerca* and *Monostyla*) formed 7.8% of plankton followed by Copepods (*Diaptomus, Cyclops*; 5.7%)(List of plankton is given in Table 6).

Periphyton :- Periphytic population ranged from 1746 in post-monsoon to 2134 u/cm^2 in winter. Periphytic communities of the reservoir were dominated by bacillariophyceae both qualitatively and quantitatively (Fig. 3c). It formed 68.9% of periphyton and were represented by *Synedra, Stauroneis, Diatoma, Caloneis Fragilaria, Amphora, Gyrosigma, Melosira* and *Cymbella.*

Macrobenthos :- The bottom fauna of the reservoir was dominated by Chironomods (52.4%; Table 7). The average standing crop of benthos was rich (1083 u/m^2) which may be due to high content of organic carbon in the soil. Molluscs formed 18.5% of the total benthos. Tubificids constituted 16.9%while **Chaoborus** formed 9.2%.

Macrovegetation :- Aquatic weeds such as *Hydrilla, Vallisneria, Potamegton,Elodea* occurred only in winter season (Table 8) at @ 0.24 kg/m^2 wet wt.

3.4 Fisheries

The Orai reservoir is being exploited by a contractor to whom the fishing rights are leased for a period of three years through open auction. Fishing is irregular and is conducted by fishing parties brought from other towns. Gill-nets are the dominant gear followed by drag nets and hook and lines. Available records on stocking reveals stocking of the reservoir varied from 0.75 lakh fry in 1996-97 to 11.00 lakh fry in 2000-01. The average stocking was 720 fry/ha/A (Table 9).

The fish yield in Orai has increased from 66.1 in 1999-2k to 122.1 kg/ha in 2k-01. Catch statistics of 2000-01 revealed landings of 46.9 t of fish from the reservoir was mainly dominated by major carps

(50%) in which *C. catla* was abundant . Cat fishes accounted 24% of the catch . *M. seenghala, W. attu* and *T. tor* were prevalent. Other common fishes in the catch were *L. gonius, N. notopterus , N. chitala, C. reba, P. sarana, E. vacha, M. armatus* and *O. cotio* accounted 26% of the catch (Table 10). The size of catla and mahaseer in the catches of Orai indicate good growth of both the species.

3.5 Management guidelines

Orai is around thirty years old reservoir having an another impoundment named Bassi attached to its right bank. It receives water from Orai river. The plankton and bottom fauna are at moderate density with dominance of chlorophyceae in the former and chironomids in the latter. The catch consisted of catla , mahaseer, seenghala etc. The present fish yield of 122 kg/ha better than other reservoirs can further be improved by adopting proper stocking to realize the potential yield of 375 kg/ha. Emphasis should be given to stock mrigala, rohu and catla @ 700 fingerlings/ha besides stocking of *Tor tor*. Being a irrigation reservoir the water level invariably goes down drastically in summer due to exigencies of water requirement. The extent of reduction in area thus should be taken into consideration for fisheries development program. Regular fishing with the use of gill-nets (40-60 mm mesh bar) is suggested.

4 GAMBHIRI RESERVOIR

4.1 Morphometric and hydrology characteristics

Gambhiri, an old impoundment across the river Gambhiri a tributary of the river Banas, is located at latitude 24°-42'N and is situated around 35 km away from Chittorgarh town. The earth-fill dam was constructed mainly for flood control and irrigation purposes in the year 1967. The upper reaches of reservoir surrounds by hills of Aravali range. The reservoir has a water spread area of 2336 ha at FTL and a catchment area of 1036 km^2. It falls under the medium reservoir category. The low mean depth of 3.2 m indicate shallow character. The ratio of catchment/area (considered to be an index of allochthonous inputs) is moderate (44) reflecting inputs of nutrients through the catchment. The atmospheric temperature varied from 22 in post-monsoon to 25°C in pre-monsoon during the course of survey. The average rainfall in the area is 711 mm (Table 1).

4.2 Limnology and productivity

Soil quality :- Basin soil was sandy loam in texture. Soil was alkaline (pH 7.43) and was deficient with regards to available phosphorus (0.62 mg/100g) and available nitrogen (7.56 mg/100g). Organic carbon (0.77%) in the soil was moderate (Table 2).

Water quality :- The water temperature varied from 19.0 in post-monsoon to 25.0°C in pre-monsoon. The alkaline (pH 7.1) water enable the normal ion exchange of fresh water fishes and is favourable for fish growth. Transparency ranged between 11.0 and 58.0 cm (Table 3). Low wind turbulence in winter could have resulted in high transparency. Dissolved oxygen was congenial with mean value of 6.0 mg/l. The seasonal variation in total alkalinity was discernible with minimum value of 60 mg/l in monsoon and

110 mg/l in winter. The average total alkalinity (90 mg/l) was found conducive to high fish productivity. Higher ionic concentration (292 µmhos/cm) indicated eutrophic conditions.

Calcium concentration was found to be moderate (22.0-32.0 mg/l). Magnesium content varying between 5.2 and 22.1 was of high order. Total hardness exhibited the trend of magnesium. The mean value of chloride was 4.7 mg/l. The concentration of phosphorus (Table 3) is moderate considering 0.05 to 0.20 mg/l of phosphorus as favourable for productivity. It varied from 0.06 to 0.10 mg/l. Depth-wise observations did not show presence of thermal stratification. Chemical parameters (Table 4.4) showed signs of weak chemical stratification.

Studies on primary productivity showed an gross carbon production of 1221 mgC/m²/d (Table 5). Energy assimilation efficiency (68.1%) indicated productive character of the reservoir. The potential yield in terms of carbon production is 450 kg/ha. The reservoir thus falls in highly productive category.

4.3 Biotic communities

Plankton :- Studies on plankton distribution and abundance reflected 2940 u/l of plankton in Gambhiri reservoir (Fig. 2d). Myxophyceae formed 33.4% of the total plankton and were mainly represented by *Microcystis* and *Oscillatoria.* Chlorophyceae constituted 24.6% followed by dinophyceae (8.0%) and bacillariophyceae (3.8%). The list of planktons recorded from Gambhiri reservoir is given in table. Rotifers *(Colurella, Trichocerca, Keratella, Brachionus, Filinia* and *Notholca*) formed 16.7% of plankton followed by Copeods (*Diaptomus, Cyclops*; 7.1%) (List of plankton is given in Table 6).

Periphyton :- Periphytic communities varied from 2015 to 2325 u/cm² (Fig. 3d) and were dominated by bacillariophyceae (74.6%). *Frustulia, Diatoma, Tabellaria, Navicula, Achnanthes, Melosira, Amphora, Stauroneis, Synedra, Fragilaria* were common in periphyton.

Macrobenthos :- The standing crop of benthos was rich (1675 u/m²) which may be due to moderate content of organic carbon in the soil. Chironomids dominated the fauna forming 68.6% of the population followed by *Chaoborus* (13.4%), tubificids (10.0%) and molluscs (10.0%)Table 7.

Macrovegetatyion :- Aquatic weeds were altogether absent during the course of investigation.

4.4 Fisheries

Fishing in the reservoir is irregular and is being conducted by fishing parties engaged by a contractor to whom the reservoir is leased out for a period of three years through an open auction. Gill-nets are dominant gears followed by drag-nets and cast nets. These appears to be no mesh regulation, as is evident from the use of small meshed nets (<40 mm). No agency seems to monitor the catch at the reservoir. Available records on stocking for the year 1996-97 to 2001-02 indicated stocking of IMC fries at an average of 794 nos./ha ranging from 0.45 lakh of fries in 1997-98 to 32.0 lakh fries in 2000-01 (Table 9).

The fish yield in Gambhiri has increased from 33.0 in 2000-01 to 56 kg/ha in 2001-02. Estimated catch in the year 2001-02 was 77.8 t mainly dominated by major carps (65.6%) (Table 10). Thus, the Indian major carps accounted for fairly good production in the catches. The common species reported from the reservoir were *C. catla, L. rohita, C. mrigala, L. bata, L. gonius, L. calbasu, C. marulius, O. bimaculatus, M. seenghala, W. attu* and *M. armatus*.

4.5 Management guidelines

This is a modern sized impoundment of Banas basin with high productive potential. The plankton and bottom fauna are rich having dominance of myxophyceae in the former and chironomids in the later. The catch consisted of stocked carps and indigenous fishes. The potential of the reservoir could be realized with stocking of mrigal, rohu and catla. It would be better to stock the reservoir with 800 fingerlings/ha on continuous basis instead of present practice of heaving stocking of fries. Gill-nets of mesh bar 40-80 mm may be employed for fishing. There is ample scope for pen culture operation for seed rearing.

5. UDAISAGAR RESERVOIR

5.1 Morphometry and hydrological characteristics

The morphometric and hydrology parameters of Udaisagar presented in Table 1. Udaisagar , an impoundment across the river Bedach a tributary of river Banas is located at latitude 24°-33" near Udaipur town. It is an oldest impoundment having been formed in 1565. The catchment of the reservoir is surrounded by hills of Aravali ranges. It has a water spread area of 440 ha at FTL and a catchment area of 31.1 km^2. The low depth of 7.0 m indicate shallow character. The ratio of catchment/area is high (109) indicating inputs of nutrient through the catchment. The atmospheric temperature varied from 21.8 in winter to 29.0°C in post-monsoon. The average rainfall in the area is 635 mm (Table 1).

5.2 Limnology and productivity

Soil quality :- Basin soil of the reservoir was sandy (sand 67.5%) in texture and was alkaline (pH 7.38) in reaction (Table 2). It was deficient with regards to available phosphorus (0.12 mg/100g) and levels of the reservoir. The organic load is reflected in high level of organic carbon (1.03%).

Water quality :- The water temperature was minimum in winter (16.0) while maximum temperature was in pre-monsoon (25.5°C). The alkaline water (pH 7.7) enable the normal ion-exchange of fresh water fishes and is favourable for fish growth. Transparency ranged from 31.0 cm in pre-monsoon to 116 cm in winter (Table 3). Low wind turbulence in winter could have resulted in high transparency. Dissolved oxygen was quite good varying from 7.2 to 8.4 mg/l. Free CO_2 was absent in all the seasons. The average total alkalinity (86 mg/l) was nearly conducive to fish productivity. Higher ionic concentration (1216 µmhos/cm) indicated eutrophic conditions.

Calcium concentration was found to be moderate (20-28 mg/l). Magnesium content varied between 14.4 and 23.4 mg/l and was of high order. Total hardness reflected the trends of magnesium. The mean value of chloride was high (15.5 mg/l). The concentration of phosphorus (0.002-0.01 mg/l) was poor while the silicate (1.8-3.0 mg/l) was moderate. The low concentration of nutrient may be due to quick turn over of these elements or their loading from catchment is of low order.

Depth profile of the reservoir did not show presence of thermal stratification (Table 4.5).

Observations on primary productivity exhibited an average gross carbon production of 1374 mgC/m^2/d (Table 5). Energy assimilation efficiency (63.7%) reflected productive character of the reservoir. The potential fish yield in terms of carbon production is 500 kg/ha. The reservoir hence falls in highly productive category.

5.3 Biotic communities

Plankton :- Plankton abundance ranged from 1065 u/l in post-monsoon to 5625 u/l in pre-monsoon and had an annual average production of 3082 u/l. Myxophyceae (27.0%), chlorophyceae (22.3%) and bacillariophyceae (21.4%) contributed almost equally in the composition of plankton (Fig 2e). *Microcystis* spurt seen in pre-monsoon may be due concentrations of ions and reduced volume of water. *Hydrocoleum, Wollea* and *Cylindrospermum* occurred in Udaisagar may be ascribed to more anthropogenic stress. Diatoms were abundant in winter and mainly represented by *Meridion, Navicula, Melosira, Frustulia, Synedra, Fragilaria, Achnamthes, Amphora, Caloneis, Tabellaria* and *Cocconeis*. Chlorophyceae was mainly represented by *Spirogyra, Rhizoclonium, Scenedesmus, Botrycoccus, Oedogonium, Mougeotia* and *Zygena*. Zooplankton were mainly dominated by rotifers (*Asplanchna, Keratella, Brachionus, Filinia* and *Notholca*) constututing 14.2% of the total plankton Udaisagar receiving organic nutrients through the influx of municipal effluents could have favoured the abundance of rotifers. Copepods (*Cyclops, Diaptomus*) formed 9.4% of the total plankton (List of plankton is given in Table 6).

Periphyton :- Periphytic communities ranged between 1649 in post-monsoon to 2231 u/cm^2 in summer and had an abundance of 1972 u/cm^2 (Fig. 3e). Bacillariophyceae (69.0%) dominated over myxophyceae (19.1%) and chlorophyceae (13.5%). Ditaoms were represented by *Cymbella, Tabellaria, Calonoeis, Synedra, Gyrosigma, Diatoma, Melosira, Navicula, Stauroneis* and *Cocconeis*. Chlorophyceae were represented by *Characium* and *Cladophora*. Protozoans were represented by *Difflugia*.

Macrobenthos :- The standing crop of bottom biota was estimated as 2625 u/m^2 (Table 7). Chironomids constituted 83.8% of the total fauna followed by *Chaoborus* (9.5%) and molluscs (4.8%).

Macrovegetation :- The aquatic vegetations were altogether absent during the course of investigation (Table 8).

5.4 Fisheries

Fishing in the reservoir is irregular and is being conducted by fishing parties engaged by a contractor to whom the reservoir is leased out through open auction. Available records (Table 9)on stocking showed that stocking varied from 0.163 (1997-98) to 3.45 lakh fry averaging 508 fry/ha/A.

There was no fishing the year 2000-01. The fish yield in 1999-2000 was 172.3 kg/ha. The catch had the dominance of minor carps (70%) followed by IMC (18%) and cat fishes (12%) (Table 10).

5.5 Management and guidelines

It is an old reservoir wherein miscellaneous fishes account substantially in the catch. Major carps and cat fishes are being caught in low quantities. Obviously the low fish yield of major carps is due to low stocking rate of IMC adopted so far. The reservoir receive the nutrient through the influx of municipal effluents. It has a good population of plankton consisting of myxophyceae and chlorophyceae. Benthic standing crop was rich and consisted mainly chironomids. Addition of common carp could be considered to exploit rich bottom fauna besides stocking of catla, rohu and mrigal @ 900 fingerlings/ha to realize the potential yield. Restriction on the minimum mesh size of net used should be implemented strictly. Since reservoir is used as storage tank by Hindustan Zinc Ltd., for consumption of water for industrial purposes. The water level goes down heavily in summer. This aspect should also be taken into consideration while formulating the management program of the reservoir.

6. NANDSAMAND RESERVOIR

6.1 Morphometry and hydrological characteristics

Nandsamand, an impoundment across the river Banas is situated at latitude 25°-50'N near Nathwara in Rajsamand district (Table 1). It is around five decade old reservoir having been formed in 1957 mainly for irrigation purposes and is surrounded by hills of Aravali ranges. It has a water spread are of 407 ha at FTL and a total catchment area of 839 km^2. The catchment/area ratio is quite high (209) indicates inputs of good amount of nutrients through the catchment. The mean depth of 5.2 m reveals shallow character of the reservoir. The atmospheric temperature ranged from 24°C in post-monsoon to 27°C in summer. The catchment of the reservoir lies in dry hilly belt of Aravali ranges with low annual rain fall (55.9 cm).

6.2 Limnology and productivity

Soil quality :- Like-wise other reservoirs, the basin soil in Nandsamand is also sandy loam and alkaline in nature (Table 2). Available phosphorus of low order (0.50 mg/100g) whereas the available nitrogen (20.3 mg/100g) and organic carbon (0.81%) was of moderate range.

Water quality :- The physico-chemical parameters of water are presented in Table 3. The water temperature varied from 20.0 (post-monsoon) to 26.5°C (pre-monsoon). The alkaline water (pH 7.5)

enable the normal ion-exchange of fresh water fishes and is favourable for fish culture. The water of Nandsamand impoundment remains clear imparting a greenish tinge. Transparency fluctuated between 56 and 68 cm. Dissolved oxygen was congenial varying between 6.0 and 7.6 mg/l. Free CO_2 was absent in all the reasons. Seasonal variation in total alkalinity reflected low values during pre-monsoon (64 mg/l) and

Calcium concentration was quite moderate (23.2-32.0 mg/l). Magnesium content were also good varying from 6.2 to 11.4 mg/l. Chloride values fluctuated in the range of 3.6 – 6.5 mg/l. Dissolved organic matter (1.6-3.4 mg/l) also reflected productive character of the reservoir. Phosphate and silicate were poor/ Specific conductivity ranged from 244 to 362 µmhos/cm indicating productive state of the ecosystem.

Depth-wise observation in respect of water temperature did not show presence of thermal stratification. Chemical parameters (Table 4.6) such as D.O., HCO_2 and sp. conductivity exhibited weak chemical stratification.

Primary productivity :- The primary productivity studies revealed an average gross carbon production of 1145 mgC/m^2/d while the average net production was 742 mgC/m^2/d (Table 5). Energy assimilation efficiency (64.8%) exhibited production state of the water body. The expected fish yield in terms of carbon production is 400 kg/ha/A which shows the high productive state of the reservoir.

6.3 Biotic communities

Plankton :- The plankton population of the reservoir varied from 3342 u/l in post-monsoon to 4221 u/l in winter and had an average abundance of 3846 u/l (Fig. 2f). On an average phytoplankton formed 78.5% of total plankton. Among phytoplankters, myxophyceae out numbered chlorophyceae, forming 47.7% of the total plankton. The major pulse of myxophyceae was in post-monsoon (63.3%) while its minimum concentration (22.7%) was in winter. Blue-green algae was comprised of *Anabaena, Oscillatoria, Phormidium, Microcystis* and *Spirulina*. List of plankters recorded is given in table 6. Rotifers and copepods formed of the zooplankton. Rotifers (12.8%) were represented by *Keratella, Filinia, Brachionus, Notholca, Colurella, Trichocera* and *Hexarthra*. Occurrence *of Anabaena, Oscillatoria, Microcystis, Scenedesmus* and *Pediastrum* indicated eutrophic tendency of the reservoir.

Periphyton :- Periphytic communities (2126 u/cm^2), both qualitatively and quantitatively were dominated by bacillariophyceae (69.5%) (Fig. 3f). Diatoms were mainly represented by *Synedra, Daitoma, Merodion, Fragilaria, Navicula, Tabellaria, Frustulia* and *Cocconeis.*

Macrobenthos :- The bottom fauna of the reservoir was dominated by chironomids (58%; Table 7). The average standing crop of benthos was rich (1150 u/$m^{2)}$ which may be due to good content of organic carbon in the soil. *Chaoborus* formed 17.4% of the total benthos followed by molluscs (15.9%).

Macrovegetation :- The macrophytes abundance ranged from 0.8 kg/m2 in post-monsoon to 1.5 kg/m2 in summer. The common forms were *Hydrilla, Potamogeton* and *Vallisneira* (Table 8).

6.4 Fisheries

Available records on stocking showed poor rate of stocking (686 ha/A) of IMC fries which varied from 0.55 to 3.00 lakh (Table 9). Fish yield (kg/ha) in Nandsamand has increased from 112 in 2000-01 to estimated yield of 160 in 2001-02. Minor carps formed 53.6% of the catch followed by IMC 36.2% and cat fishes (10.2%) (Table 10). The common fishes reported from the reservoir were *M. seenghala, C. catla, T. tor, W. attu, L. rohita, C. mrigala, L. gonius, P. sarana, N. notopterus, C. reba* and *M. aramtus*.

6.5 Management guidelines

It is around five decades old reservoir whose catchment have been intercepted by dams in the upstream. The plankton and bottom fauna are moderate density. The present fish yield of 160 kg/ha can further be improved by adopting proper stocking . Emphasis should be given to stock mrigal, rohu and catla @ 750 fingerlings/ha. Being an irrigation reservoir the water level invariably goes down drastically in summer due to exigencies of water requirement. The extent of reduction in area thus should be taken into consideration for fisheries development program. Regular fishing with the use of gill-nets (40-60 mm mesh bar) in the reservoir is suggested. There is ample scope for pen culture operation for seed rearing. Poaching menace should be checked for better yield.

7. SOM KAMLA AMBA RESERVOIR

7.1 Morphometry and hydrological characteristics

Som Kamla Amba reservoir is situated at latitude 23o-58'N near village Amba in Dungarpur

mainly for irrigation purpose in the year 1999. The reservoir has a water spread area of 3618 ha at FTL and a catchment area of 5376 km^2. It has a mean depth of 4.8 m and is shallow in nature. The other salient feature of morphometry are presented in Table 1.

7.2 Limnology and productivity

Soil quality :- Basin soil of the reservoir is sandy loam (sand 68.0%) and alkaline (pH 7.52) in reaction (Table 2). The soil was deficient with regards to available phosphorus (0.13%). The low phosphorus concentration in the soil could be due to rapid assimilation of available phosphorus in the biota. The organic load in the reservoir is however reflected with the presence of rich organic carbon (1.20%) and available nitrogen (21.0 mg/100g).

Water quality :- Barring summer months, the water in Som Kamla Amba reservoir remains clear imparting a greenish tinge. Transparency fluctuated from 31 cm in summer to 212 cm in post-monsoon. Low transparency in summer may be attributed to shallowness of the reservoir coupled with high wind

action. The water temperature varied from 17 in winter to 28°C in post-monsoon. The alkaline water (pH 7.4) is favourable for fish growth. Dissolved oxygen varied from 6.0 to 8.4 (av. 7.5) mg/l. Free CO_2 was

in post-monsoon (86.0 mg/l) and maximum value in summer (188.0 mg/l). Assessment of the productivity based on total alkalinity (122 mg/l) reflected the water body fairly productive (Table 3).

Calcium content of water ranged between 27 and 30 mg/l. Magnesium concentration was of high range (8.4-21.6 mg/l). Chloride values fluctuated from 10.0 to 18.0 mg/l. High values of dissolved organic matter (4.0-4.6 mg/l) reflected high productive potential of the reservoir. Phosphates (0.012 mg/l) and silicate (2.7 mg/l) were of low to medium range respectively. Higher values of specific conductance (601 µmhos/cm) supported the eutrophic character of the reservoir. The rich water quality reflects the transport of allochthonous dissolved nutrients and their leaching in to the system.

Depth profile (Table 4.7) of the reservoir reflected absence of thermal stratification. Absence of thermocline could be due to free mixing of water because of shallowness of the reservoir. Chemical parameters such as dissolved oxygen, total alkalinity and specific conductivity at different depths showed signs of weak chemical stratification.

Primary productivity :- The average gross and net production was 1167 and 750 mgC/m²/d respectively (Table 5). The potential fish yield in terms of carbon production is 425 kg/ha/A. This shows the high productive state of the reservoir. Energy assimilation efficiency (64.3%) shows the productiveness of water body.

7.3 Biotic communities

Plankton :- Myxophyceae (53.7%) dominated the plankton population (2355 u/l) followed by chlorophyceae (20.1%), bacillariophyceae (6.0%), copepods (9.4%) and rotifers (3.6%). The dominance of myxophyceae was observed in winter (66.6%) (Fig. 2g). The common forms occurred were *Nostoc, Merismopedia, Phormidium, Microcystis* and *Spirulina.* The percentage composition of chlorophyceae fluctuated from 17.9 in summer to 21.6 in post-monsoon. *Spirogyra, Rhizoclonium, Scenedesmus, Closterium, Aphamochaete, Zygnema, Ulothrix, Crucigenia, Ankistrodesmus* and *Characiopsis* were the common of green algae. Zooplankton were mainly dominated by Copepods (*Cyclops, Diatomus*) and *rotifers (Keratella, Brachionus, Filinia, Colurella, Trichocerca* and *Hexarthra*. Occurrence of such species such as *Microcystis, Oscillatoria, Scenedesmus* indicated eutrophic tendency of the water body (The list of plankton is given in Table 6).

Periphyton :- Bacillariophyceae was rich both qualitatively and quantitatively (71.2%) among the periphytic communities (Fig. 3g). It was represented by *Cymbella, Gyrosigma, Synedra, Navicula, Notzschia, Amphipleura, Achnanthes, Meridion and Caloneis. Characium* and *Cladophora* represented chlorophyceae (13.8%). Protozoans (4.1%) were represented by *Difflugia.*

Macrobenthos :- The standing crop of macrobenthos was estimated as 1483 u/m_2 (Table 7). Chironomids dominated the fauna (42.7%) followed by molluscs (34.9%), *Chaoborus* (16.9%) and tubificids (5.5%). The high level of macrobenthos among biotic communities may be due to rich concentration of organic carbon in the soil.

Macrovegetation :- The infestation of macrophytes in the reservoir was estimated as 0.40 kg/m^2 wet wt. (Table 8). The common forms of aquatic weeds occurred were *Potamogeton, Hydrilla* and *Vallisneria.*

7.4 Fisheries

Fishing in the reservoir is being done by fishermen engaged by the contractor to whom the fishing rights are leased out for a period of three years through an open auction. Available records on stocking shows that 60.5 lakh fries of IMC were stocked during the year 1999-2k to 2k-01 (Table 9).

During the year 1999-2k, a total of 50 t of fish landed from the reservoir yielding in a fish yield of 23.0 kg/ha. The fish yield decreased to 19.4 kg/ha in 2k-01. Indian major carps formed 56.7% of the total catch followed by minor carps (33.3%) and cat fishes (10.0%) in 2k-01 (Table 10). The common species thriving in the reservoir are *C. catla, L. rohita, C. mrigala, M. seenghala, L. gonius, L. calbasu, L. bata, P. sarana* and *W. attu.*

7.5 Management and guidelines

Som Kamla Amaba is a medium sized new impoundment of Mahi basin with high productive potential. The plankton and bottom fauna are rich having dominance of myxophyceae in the former and chironomids larvae in the latter. The catch consisted of stocked carps and indigenous fishes. The potential of the reservoir could be realized with stocking of mrigal, rohu and catla and common carp. It would be better to stock the reservoir with 800 fingerlings/ha on continuous basis instead of present practice of heavy stocking of fries. Fishing under the aegis of a co-operative society formed of local population would able to solve the problem of poaching in the area. Besides giving employment to local youth. Gill-nets of mesh bar 40-80 mm may be employed for fishing. There is ample scope for pen culture operation for seed rearing.

8. WEST BANAS RESERVOIR

8.1 Morphometric and hydrological characteristics

West Banas reservoir is located at latitude 24°-41'N in the district of Sirohi, Rajasthan (Table 1). It lies across the main river West Banas, around 35 km away from Sirohi town. It has a water spread area of 940 ha at FTL and a total catchment area of 508 km^2. The reservoir is mainly constructed for irrigation in the year 1965-66 and is surrounded by hills of Aravali ranges. The out flow from Jawai reservoir joins

the river West Banas. The mean depth of 4.2 m suggest shallow character of the reservoir. The C/A ratio of 54 indicates more inputs of allochthonous nutrient through the catchment. The atmospheric temperature varied from 24 in winter to 30°Cin summer. The total rain fall in the area was 403 cm.

8.2 Limnology And productivity

Soil quality :- The basin soil of the reservoir was sandy-cum-silty (sand 44.5%; silt 41.8%) in texture and alkaline (pH 7.48) in reaction (Table 2). The available phosphorus (0.36 mg/100g) and available nitrogen (7.84 mg/100g) were poor. Low phosphorus indicates rapid assimilation of available phosphorus in the biota. The organic load in the soil is reflected by rich organic carbon (1.06%).

Water quality :- Transparency in the reservoir fluctuated from 23 cm in summer (Table 3) to 51 cm in post-monsoon. The water is alkaline (pH 7.9) which enable the normal ion-exchange of fresh water fishes. Dissolved oxygen ranged between 5.5 and 7.6 mg/l and was in congenial range. Free CO_2 was absent throughout the year. The total alkalinity (86 mg/l) was conducive to fish productivity.

Calcium (22-24 mg/l) and magnesium (5.6-12.0 mg/l) content was of high order. Total hardness varied between 114 and 125 mg/l. Chloride values fluctuated from 2.5 to 5.0 mg/l. Dissolved organic matter an important parameter of productivity ranged from 1.2 to 3.8 mg/l and indicate productive state of water body. Phosphate (0.07 mg/l) and silicate (0.40 mg/l) were low range. High values of specific conductance (av. 235 µmhos/cm) corroborated the productive state of the reservoir.

Depth-profile observations indicated almost isothermal condition. Mixing of water because of shallow reservoir condition might have prevented the formation of thermocline. Chemical parameters did not reveal much depth wise variation (Table 4.8).

Primary productivity :- The gross and net production was 834 and 454 $mgC/m^2/d$ respectively (Table 5). The potential fish yield in terms of carbon production was estimated as 300 kg/ha/A. This shows the medium productive state of the reservoir. Energy assimilation efficiency (54.4%) was nearer to the productive reservoir.

8.3 Biotic communities

Plankton :- Plankton abundance (av. 4503 u/l) fluctuated from 3777 u/l in post-monsoon to 5440 u/l in winter. Chlorophyceae comprised 52.6% of total plankton (Fig. 2h) and were mainly represented by *Rhizoclonium, Spirogyra, Botryococcus, Oedogonium, Mougeotia, Zygnema* and *Characiopsis*. Its major pulse was in post-monsoon (63.9%). Myxophyceae constituted 12.1% of the total plankton and was represented by *Anabaena, Phormidium* and *Microcystis*. The percentage composition of bacillariophyceae varied from 3.8 in summer to 15.6 in post-monsoon. List of diatoms are presented in table 6. Rotifers (*Keratella, Polyarthra, Brachionus, Notholca, Colurella, Trichocerea* and *Hexarthra*)

formed 11.0% of plankton whereas copepods (*Cyclops, Diatomus* and *nauplii*) constituted 6.31% of the plankton. Occurrence of *Anabaena, Microcystis* and *Scenedesmus* showed the eutrophic tendency of the reservoir.

Periphyton :- Periphytic communities (2061 u/cm^2) were dominated by bacillariophyceae both qualitatively and quantitatively (Fig. 3h). Diatoms (67.7%) were represented by *Synedra, Gyrosigma, Cymbella, Navicula, Fragilaria, Tabellaria* and *Stauroneis*.

Macrobenthos :- The standing crop of benthic macrofauna was estimated as 3684 u/m^2 (Table 7). Chironomids dominated the fauna (83.8%) followed by by *Chaoborus* (8.1%) and molluscs (8.1%). Maximum concentration of benthos were in winter season.

Macrovegetation :- The aquatic weeds were absent during the period of investigation (Table 8).

8.4 Fisheries

Fishing in the reservoir is being conducted by fishing parties engaged by contractor to whom the nets and hook and lines are provided by the contractor. Stocking on an average in the reservoir was @ 517 fries/ha varying from 1.0 lakh fries in 1997-98 to 7.00 lakh fries of IMC in 2001-02 (Table 9).

A total of 152.9 t of fish landed from all over the reservoir during the year 2000-01 yielding in a fish yield of 271 kg/ha. The fish yield decreased to 188 kg/ha ion 2001-02. Indian major carps constituted 75.4% of the total catch in 01-02 followed by minor carps (12.9%) and cat fishes (11.7%) (Table 10). *C. catla* and *L. rohita* were dominant in West Banas. Other fishes reported were *W. attu, M. seenghala, M. armatus, O. bimaculatus, C. marulius, P. sarana* and *L. gonius*. The fish spectrum shows presence of good population of predators in the ecosystem. Thus the size of fish seed for stocking would be an important factor for better survival of major carps.

8.5 Management guidelines

The limnological investigations of West Banas suggest the medium productive status of the water body with an estimated production potential of 300 kg/ha. Though it has good population of fish food organisms its production potential compared to other reservoir is low. The reservoir needs stocking support with emhasis on catla, rohu and mrigal to relaize the potential. The fingerlings @ 550/ha may be stocked. Gill-nets of 40-60 mm mesh bar may be used regularly. Exploitation of reservoir under the aegis of co-operative society may be probed. The pen culture system can be introduced in this reservoir to boost the fish yield.

9. JAWAI RESERVOIR

9.1 Morphometric and hydrological characteristics

The morphometric and hydrological features of Jawai reservoir are presented in table 1. The reservoir is situated at latitude 25°-6'N in the district of Pali. The impoundment is located across the river Jawai which originates from the eastern slopes of Aravali ranges. It was constructed in the year 1957 mainly for drinking purposes to fed peoples of Jodhpur town. The reservoir is surrounded by hills of Aravali ranges and has a water spread area of 2590 ha at FTL and a total catchment area of 787 km^2. In order to supplement the available storage, water is added through a canal from near by Sei reservoir. The C/A ratio of 30 indicate low inputs of allochthonous nutrients through the catchment compared to other reservoir investigated during the survey. The mean depth of the reservoir is 7.7 m. The atmospheric temperature varied from 28 in winter to 30°C in post-monsoon. The total rain fall in area was 81.3 cm.

9.2 Limnology and productivity

Soil quality :- The basin soil was sandy-cum-silty (sand 45.6% and silt 38.8%) and alkaline (pH 7.5) in reaction (Table 2). The soil was deficient with regards to available phosphorus (0.36 mg/100g). The low phosphorus concentration in the soil reflects rapid assimilation of available phosphorus in the biota. Available nitrogen (19.04 mg/100g) was of moderate level. The organic load in the soil was reflected by the presence of good level of organic carbon (1.30%).

Water quality :- The water in Jawai reservoir remains clean imparting greenish tinge. Transparency fluctuated from 54 cm in summer to 150.0 cm in post-monsoon. Shallowness of the reservoir coupled with high wind action in summer affected the transparency (Table 3). The water was lowest in winter (22°C) while it was maximum summer (26.5°C). The water was alkaline (pH 7.9) in reaction which enables the normal ion-exchanges of fresh water fishes. Dissolved oxygen varied from 5.3 to 8.8 (av. 7.2) mg/l). Free CO_2 was absent in summer and winter while it appeared at 1.6 mg/l concentration in post-monsoon. The seasonal variation in total alkalinity was quite discernible with minimum value in post-monsoon (90 mg/l) and maximum in summer (110 mg/l). The average total alkalinity (98 mg/l) indicated conduciveness of water body for higher fish productivity.

The productive nature of the reservoir was also evident with the higher value of calcium (25-35 mg/l) and magnesium (6.8-21.0 mg/l) contents of water. Dissolved organic matter ranging from 1.0 to 2.2 mg/l also reflected productive character of water body. The productive state of the reservoir was also exhibited by higher values of electric conductance varying from 248 in post-monsoon to 322 µmhos/cm in winter. The rich water quality reflects the allochthonous inputs as organic matter and nutrients into the system.

Observations in respect of water temperature at different depths (Table 4.9) did not show presence of thermal stratification in the reservoir as the temperature difference from surface to bottom (10 m) never exceeded beyond 1.5°C. Formation of thermocline could have been prevented due to mixing of water and

shallowness of the reservoir. Chemical parameters like dissolved oxygen, total alkalinity and specific conductivity showed signs of weak chemical stratification.

Primary productivity :- The average gross production was 1236 mgC/m²/d while the average net production was 697 mgC/m²/d (Table 5). Energy assimilation efficiency (56.4%) place the reservoir in the productive category. The potential yield in terms of carbon production was estimated as 500 kg/ha/A. This shows the high productive state of the reservoir.

9.3 Biotic communities

Plankton :- The plankton population ranged from 3556 u/l in post-monsoon to 4683 u/l in summer and had an annual average abundance of 4306 u/l. Myxophyceae formed 44.5% of the total plankton population (Fig. 2i). The major pulse was observed during summer (85.0%) dye to spurt in Microcystis. The other common forms observed were *Anabaena, Oscillatoria, Merismopedia, Phormidium* and *Lyngbya*. Chlorophyceae constituted 21.7% of the total plankton and had dominance in post-monsoon. The percentage composition of bacillariophyceae flucutated from 3.3 in summer to 13.8% in winter. *Navicula, Gyrosigma, Synedra, Frustulia* and *Meridion* were the common forms of diatoms. Dinophyceae (3.2%) was represented by *Peridinium*. Zooplankton were mainly dominated by rotifers (*Keratella, Branmchionus, Notholca, Colurella*, *Trichocerca* and *Monostyla*) which formed 7.7% of total plankton. Copepods (*Diaptomus, Cyclops* and *nauplii*) constituted 5.8% of the plankton. Pollution indicator species such as *Anabaena, Phormedium* and *Oscillatoria* were rarely encountered. This showed the predominance of clean water indictor species in the system (List of plankton is given Table 6).

Periphyton :- Periphyton population ranged between 1860 u/cm² in post-monsoon and 2325 u/cm² in winter and had an average abundance of 2106 u/cm² (Fig. 3i). Bacillariophyceae (67.1%) dominated over myxophyceae (15.2%), chlorophyceae (14.0%) and animalcules (3.7%). Bacillariophyceae thus was rich both quantitatively and qualitatively and was represented by *Gyrosigma, Frustulia, Navicula, Nitzschia, Tabellaria, Epithemia, Mastogloia, Caloneis, Syendra, Fragilaria* and *Hantzschia. Characium, Cladophora* represented chlorophyceae.

Macrobenthos :- Macrobenthos of Jawai reservoir were poor in abundance (350 u/m²) due to rocky substra. It ranged from 300 u/m² in summer to 400 u/m² in winter. The bottom fauna were dominated by chironomids (38%) and molluscs (38%). *Chaoborus* constituted 14.3% while *tubificids* formed 9.7% (Table 7).

Macrovegetation :- The reservoir was devoid of aquatic weeds (Table 8).

9.4 Fisheries

Available records on stocking revealed erratic stocking of fries of Indian major carps varying from 10.94 lakh in 199-2k to 56.76 lakh in 1997-98. The average stocking was 2200/ha (Table 9). Thus, the

reservoir appears to have been over stocked. No standard on size and species of stocked fish seed have been followed. Fishing in the reservoir and is being carried out by fishing parties brought from other towns. Fishing gear employed in the reservoir are mainly of two types viz. gill-nets and hook and lines. During the year 2000-01, there was no fishing. A total of 126.18 t of fish landed from the reservoir yielding 97 kg/ha fish yield in 2001-02 (Table 10). Indian major carps formed 79.8% of the total catch. It followed by minor carps (9.4%), miscellaneous fishes (6.9%) and cat fishes (3.9%). The catch statistics indicate presence of good population of Indian major carps. Obviously it was the impact of stocking of IMC. The size of *L. rohita* and *Tor tor* in the catches of Jawai indicate good growth of both the species. It is difficult to arrive at a definite conclusion on the fishery based on the meager sampling during the survey. Fish spectrum of the reservoir was represented by *C. catla, L. rohita, C. mrigala, L. calbasu, L. gonius, L. bata, P. sarana, N. notopterus, O. bimaculatus, T. tor, W. attu* and *M. seenghala*.

9.5 Management guidelines

Jawai is a medium reservoir wherein major carps contribute substantially in the catches. Obviously it was the impact of regular stocking (av. 2200 fry/ha). It has rich population of plankton consisting of myxophyceae and chlorophyceae. A stocking program, 850 fingerlings/ha, with emphasis on mrigal (4) alongwith rohu (3) and catla (3) besides stocking of mahaseer should be undertaken to realize the production potential. Presently, heavy stocking of catla that too to fry stage could be one of the reasons for moderate fish yield (97 kg/ha) inspite of high production potential. Fish production can further be enhanced significantly by adopting judicious exploitation policy. The use of small sized gill-nets (<40mm) be checked which causes the mortality of fish at younger stage vis-à-vis reduction in autostocking. Gill-nets of mesh bar 40 to 60 mm may be used regularly instead of their seasonal use. The reservoir has good scope to boost the fish yield by introduction of pen and cage culture system. Exploitation of reservoir under the aegis of co-operative society may be probed. This will help in prevention of poaching as well as to provide employment to local youth.

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Table 4.1: Depth profile of Khari reservoir

Depth	Water temperature (°C)			pH			D.O. (ppm)		
(m)	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	28.0	30.0	15.5	7.60	7.84	7.15	8.0	7.6	7.6
2	28.0	29.0	15.5	7.66	7.80	7.15	7.2	7.2	7.2

Depth	Free CO^2			Total alkalinity (ppm)			Sp. conductivity (umhos/cm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	Nil	Nil	Nil	130.0	137.2	139.2	446.0	491.0	355.0
2	Nil	Nil	Nil	136.0	139.4	143.4	450.0	493.0	359.0

Table 4.2: Depth profile of Kothari reservoir

Depth	Water temperature (°C)			pH			D.O. (ppm)		
(m)	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	28.0	28.0	16.0	7.72	7.84	7.23	5.6	6.8	8.0
2	28.0	28.0	16.0	7.73	7.80	7.24	5.2	6.8	7.6
4	-	27.5	15.5	-	7.74	7.25	-	6.4	6.8
6	-	27.0	-	-	7.32	-	-	6.0	-

Depth	Free CO^2			Total alkalinity (ppm)			Sp. conductivity (umhos/cm)		
(m)	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	Nil	2.6	5.0	116.0	82.0	110.0	438.0	177.0	289.0
2	Nil	2.8	6.0	120.0	90.0	112.0	451.0	225.0	295.0
4	-	2.8	8.0	-	100.0	112.0	-	244.0	297.0
6	-	3.2	-	-	112.0	-	-	253.0	-

Table 4.3: Depth profile of Orai reservoir

Depth	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	28.0	27.0	16.0	7.83	7.77	6.73	7.2	6.8	8.4
2	28.0	26.5	16.0	7.83	7.67	6.74	6.4	6.8	8.0
4	27.0	26.5	15.0	7.83	7.58	6.76	6.0	6.8	7.2
6	-	26.0	-	-	7.54	-	-	6.4	-
8	-	26.0	-	-	7.31	-	-	6.0	-

Depth	Free CO^2			Total alkalinity (ppm)			Sp. conductivity (umhos/cm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	Nil	3.6	Nil	108.0	86.0	98.0	285.0	174.0	220.0
2	Nil	3.6	Nil	108.0	90.0	102.0	279.0	176.0	230.0
4	Nil	4.0	Nil	112.0	92.0	106.0	279.0	178.0	231.0
6	-	5.0	-	-	96.0	-	-	178.0	-
8	-	5.2	-	-	96.0	-	-	178.0	-

Table 4.4: Depth profile of Gambhiri reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	25.0	19.0	22.0	6.24	7.66	7.52	5.68	5.6	6.8
2	-	18.5	22.0	-	7.66	7.58	-	5.2	6.8
4	-	18.0	-	—	7.67	-	-	5.0	-
6	-	18.0	-	—	7.67	-	-	5.0	-

Depth (m)	Free CO^2			Total alkalinity (ppm)			Sp. conductivity (umhos/cm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	4.0	Nil	Nil	60.0	104.8	114.8	331.0	261.0	283
2	-	Nil	Nil	-	107.0	119.6	-	263.0	284
4	-	Nil	-	-	117.0	-	-	264.0	-
6	-	Nil	-	-	119.2	-	-	265.0	-

Table 4.5: Depth profile of Udai Sagar reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	25.5	24.0	16.0	7.01	8.55	7.70	8.80	6.72	8.4
2	-	-	16.0	-	-	7.73	-	-	8.4

Depth	Free CO^2			Total alkalinity (ppm)			Sp. conductivity (umhos/cm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	Nil	Nil	Nil	142.0	68.0	98.0	1000	910	1739
2	-	-	Nil	-	-	105.0	-	-	1732

Table 4.6: Depth profile of Nand Samand reservoir

Depth	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	26.5	20.0	21.0	8.21	7.35	7.0	7.2	6.0	7.6
2	26.0	19.5	20.5	8.21	7.37	7.01	6.6	5.4	6.4
4	-	19.0	20.0	-	7.50	7.09	-	5.4	5.6
6	-	18.5	-	-	7.52	-	-	5.2	-

Depth	Free CO^2			Total alkalinity (ppm)			Sp. conductivity (umhos/cm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	Nil	Nil	Nil	75.0	119.6	125.4	244.0	336.0	362.0
2	Nil	Nil	Nil	82.0	124.0	129.6	246.0	332.0	382.0
4	-	Nil	Nil	-	124.0	131.6	-	331.0	386.0
6	-	Nil	-	-	126.0	-	-	330.0	-

Table 4.7: Depth profile of Som Kamla Amba reservoir

Depth	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	25.5	28.0	17.0	8.12	7.69	6.49	8.0	8.4	6.0
2	-	27.5	16.5	-	8.30	6.52	-	8.0	5.6
4	-	27.0	16.4	-	7.35	6.59	-	6.0	5.6
6	-	26.3	16.0	-	7.94	6.61	-	5.6	5.2
8	-	26.0	-	-	7.95	-	-	5.2	-

Depth	Free CO^2			Total alkalinity (ppm)			Sp. conductivity (umhos/cm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	Nil	Nil	Nil	205.8	86.0	95.0	881	429	494
2	-	Nil	Nil	-	90.0	103.2	-	414	495
4	-	Nil	Nil	-	90.0	117.6	-	412	502
6	-	Nil	Nil	-	92.0	133.8	-	411	505
8	-	Nil	-	-	96.0	-	-	402	-

Table 4.8: Depth profile of West Benas reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	27.0	20.5	21.0	8.20	7.78	7.92	6.0	5.52	7.6
2	26.5	20.0	21.0	8.23	7.79	7.78	5.4	5.0	7.2

Depth	Free CO^2			Total alkalinity (ppm)			Sp. conductivity (umhos/cm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	Nil	Nil	Nil	86.6	91.6	90.0	202	233	269
2	Nil	Nil	Nil	88.8	96.0	94.6	189	236	265

Table 4.9: Depth profile of Jawai reservoir

Depth	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	26.5	22.0	22.0	8.46	7.58	7.81	7.6	5.32	8.8
2	26.2	22.0	22.0	8.45	7.60	7.86	7.2	5.20	7.6
4	26.2	21.5	21.0	8.40	7.64	7.89	6.4	5.0	7.2
6	26.0	21.5	-	8.38	7.66	-	5.6	5.0	-
8	-	21.0	-	-	7.67	-	-	4.8	-
10	-	20.5	-	-	7.68	-	-	4.4	-

Depth	Free CO^2			Total alkalinity (ppm)			Sp. conductivity (umhos/cm)		
	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter	Summer	Post-monsoon	Winter
Surface	Nil	1.6	Nil	115.0	90.0	94.0	319	248	322
2	Nil	1.8	Nil	118.0	92.0	96.0	309	249	341
4	Nil	1.8	Nil	123.0	94.0	98.0	306	249	343
6	Nil	2.0	-	128.0	94.0	-	305	250	-
8	-	2.4	-	-	96.0	-	-	252	-
10	-	2.4	-	-	98.0	-	-	253	-

Table : 1 : Location, morphometric and hydrological features of reservoirs of Rajasthan.

Reservoirs/ Parameters	Khari	Kothari	Orai	Gambhiri	Udaisagar	Nand-samand	Som Kamla Amba	West Benas	Jawai
Location									
(i) District	Bhilwara	Bhilwara	Chittorgarh	Chittorgarh	Udaipur	Rajsamnd	Dungarpur	Sirohi	Pali
(ii) Latitude (N)	20°-42'	25°-18'	25°-2'	24°-42'	24°-33'	25°-50'	23°-56'	24°-41'	25°-6'
(iii) Longitude (E)	74°-17'	75°-0'	74°-4'	74°-43'	73°-47'	75°-47'	74°-02'	72°-57'	73°-9'
River	Khari	Kothari	Orai	Gambhiri & Kadmoli	Bedach	Benas	Som	West Benas	Jawai
Year of construction	1956	1990	1972-73	1967	1565	1957	1999	1965-66	1957
Water spread (ha) (A) at FTL	773	785	640	2336	440	407	3618	940	2590
Av. area (ha)	464	471	384	1402	264	244	2170	564	1554
Catchment (km^2) (C)	712	2176	220	1036	479	839	5376	508	787
C/A	92	277	34	44	109	206	149	54	30
Capacity (10^6m^3)	39.0	26.0	35.3	76.5	31.1	21.2	172.5	39.0	198.2
Mean depth (m)	5.0	3.3	5.5	3.2	7.0	5.2	4.8	4.2	7.7
Rain fall (mm)	630	690	600	711	635	559	297	403	813

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

Reservoirs/ Parameters	Khari	Kothari	Orai	Gambhiri	Udaisagar	Nand-samand	Som Kamla Amba	West Benas	Jawai
Sand (%)	72.8	36.0	64.1	45.5	67.5	47.2	68.0	44.5	45.6
Silt (%)	18.7	38.8	30.5	38.7	25.4	39.5	27.7	41.8	38.8
Clay (%)	8.5	25.2	5.4	15.8	7.1	13.3	4.3	13.7	15.6
pH	7.27	7.65	7.2	7.43	7.38	7.68	7.52	7.48	7.5
Org. carbon (%)	0.45	0.43	0.91	0.77	1.03	0.81	1.20	1.06	1.38
Cal. Carbonate (%)	4.2	5.4	8.2	15.0	9.75	11.25	3.75	5.25	5.38
Avail. Phosphorus (mg/100g)	0.12	0.24	0.16	0.62	0.12	0.50	0.13	0.36	0.36
Avail. Nitrogen (mg/100g)	9.38	6.72	10.5	7.56	8.4	20.3	21.0	7.84	19.04
El. Conductance (µmhos/cm)	301	370	305	319	938	372	372	235	235

Table : 3 : Physico-chemical characteristics of water (mean range) in reservoirs of Rajasthan.

Reservoirs/ Parameters	Khari	Kothari	Orai	Gambhiri	Udaisagar	Nand-samand	Som Kamla Amba	West Benas	Jawai
Temp. (°C)	**24.5** (15.5-30.0)	**24.0** (16.0-28.0)	**23.7** (16.0-28.0)	**22.0** (19.0-25.0)	**21.8** (16-25.5)	**22.5** (20-26.5)	**23.5** (17-28)	**22.8** (20.5-27.0)	**23.5** (22-26.5)
Transp. (cm)	**54.7** (44-64)	**96.0** (33-197)	**85.5** (51-155)	**38.7** (11-58)	**81.7** (31-116)	**61.7** (56-68)	**116.7** (31-212)	**40.0** (23-51)	**89.0** (54-150)
pH	**7.5** (7.1-7.8)	**7.6** (7.2-7.8)	**7.4** (6.7-7.8)	**7.1** (6.2-7.7)	**7.7** (7.0-8.5)	**7.5** (7.0-8.2)	**7.4** (6.5-8.1)	**7.9** (7.8-8.2)	**7.9** (7.5-8.5)
D.O. (mg/l)	**7.7** (7.6-7.8)	**6.8** (5.6-8.0)	**7.5** (6.8-8.4)	**6.0** (5.6-6.8)	**8.1** (7.2-8.8)	**6.9** (6.0-7.6)	**7.5** (6.0-8.4)	**6.4** (5.5-7.6)	**7.2** (5.3-8.8)
Free CO_2 (mg/l)	Nil	**2.5** (Nil-5.0)	**1.2** (Nil-3.6)	**1.3** (Nil-4.0)	Nil	Nil	Nil	Nil	**0.5** (Nil-1.6)
HCO_3 (mg/l)	**131** (130-132)	**103** (82-116)	**95** (86-108)	**90** (60-110)	**86** (60-106)	**99** (64-120)	**122** (86-188)	**86** (82-90)	**98** (90-110)
Conductance (µmhos/cm)	**431** (355-491)	**301** (177-438)	**226** (174-285)	**292** (261-331)	**1216** (910-1739)	**314** (244-362)	**601** (429-881)	**235** (202-269)	**296** (248-322)
Hardness (mg/l)	**113** (105-120)	**108** (100-115)	**112** (105-117)	**133** (112-172)	**153** (105-188)	**116** (112-120)	**163** (113-210)	**120** (114-125)	**156** (142-176)
Calcium (mg/l)	**21.3** (20-24)	**27.7** (24-32)	**30.3** (25-36)	**26.4** (22-32)	**24.7** (20-28)	**28.0** (23-32)	**28.3** (27-30)	**27.0** (22-29)	**29.3** (25-35)
Magnesium (mg/l)	**14.2** (13.2-15.0)	**9.2** (8.4-9.6)	**12.2** (9.6-15.6)	**13.3** (5.2-22.1)	**17.0** (14.4-23.4)	**8.4** (6.2-11.4)	**13.4** (8.4-21.6)	**9.7** (5.6-12.0)	**15.7** (6.8-21.0)
DOM (mg/l)	**5.5** (3.6-6.8)	**4.4** (3.2-6.0)	**5.2** (3.4-6.4)	**2.3** (1.0-3.2)	**7.3** (4.6-10.8)	**2.7** (1.6-3.4)	**4.3** (4.0-4.6)	**2.8** (1.2-3.8)	**1.7** (1.0-2.2)
Phosphate (mg/l)	**0.032** (0.006-0.08)	**0.033** (0.006-0.08)	**0.005** (0.002-0.08)	**0.08** (0.06-0.10)	**0.08** (0.002-0.01)	**0.007** (0.06-0.10)	**0.012** (0.01-0.016)	**0.07** (0.03-0.09)	**0.03** (0.02-0.04)
Silicate (mg/l)	**1.8** (1.2-2.4)	**2.2** (2.0-2.4)	**2.4** (1.8-2.6)	**0.26** (0.24-0.30)	**2.3** (1.8-3.0)	**0.27** (0.16-0.40)	**2.7** (2.4-3.0)	**0.40** (0.24-0.60)	**0.5** (0.2-0.9)
Chloride (mg/l)	**9.2** (7.5-11.0)	**7.1** (5.0-8.3)	**6.4** (3.3-9.0)	**4.7** (4.2-5.2)	**15.5** (3.5-35.0)	**4.8** (3.6-6.5)	**13.3** (10.0-18.0)	**4.0** (2.5-5.0)	**4.9** (4.2-5.6)

Table : 5 : Primary production ($mgC/m^2/d$) in reservoirs of Rajasthan.

Reservoirs	GP	NP	Respiration	% of NP in GP	% of respiration in GP
Khari	1375	861	617	62.6	44.8
Kothari	971	583	500	60.0	51.5
Orai	1028	639	433	62.2	42.1
Gambhiri	1221	832	450	68.1	36.9
Udaisagar	1374	875	600	63.7	43.7
Nandsamand	1145	742	483	64.8	42.2
Som Kamla Amba	1167	750	567	64.3	48.6
West Benas	834	454	430	54.4	51.6
Jawai	1236	697	646	56.4	52.3

Table : 6: Plankton forms encountered in reservoirs of Rajasthan.

Reservoirs/ Parameters	Khari	Kothari	Orai	Gambhiri	Udaisagar	Nand-samand	Som Kamla Amba	West Benas	Jawai
MYXOPHYCEAE									
Anabaena	P	P				P		P	P
Oscilatoria	P	P	P	P	P	P			P
Nostoc		P	P				P		
Merismopedia							P		P
Phormedium	P	P			P	P	P	P	P
Cocchochloris	P		P		P		P		
Microcystis	P	P	P	P	P	P	P	P	P
Spirulina		P	P			P	P		
Hydrocoleum					P				
Wollea					P				
Cyclindrospermum					P				
Lyngbya									P
DINOPHYCEAE									
Peridinium		P	P	P		P		P	P
Cyctodinium		P		P		P		P	
CHLOROPHYCEAE									
Spirogyra	P				P		P		P
Rhizoclonium	P	P	P	P	P	P	P	P	P
Scenedesmus	P	P	P	P	P	P	P	P	P
Botryococcus		P	P		P			P	P
Closterium							P		
Ahanochaete							P		

Reservoirs/ Parameters	Khari	Kothari	Orai	Gambhiri	Udaisagar	Nand-samand	Som Kamla Amba	West Benas	Jawai
Characium	P	P	P		P			P	P
Oedogonium	P	P			P			P	
Mougeotia	P		P	P	P		P	P	
Zygnema	P		P	P	P	P	P	P	P
Crucigenia	P		P		P		P		
Ulothrix			P						
Protococcus	P		P						
Characiopsis	P		P	P	P		P	P	P
Ankistrodesmus	P		P				P		
Volvox	P								
Pleurogaster			P		P		P		
Schizodictyon							P		
Cerasterias			P						
Tetraedron			P						
Chlarococcum	P		P		P		P		
Trachiscia		P	P			P		P	P
Pediastrum	P	P		P		P	P	P	P
Cosmarium		P		P	P	P	P		P
Pachycladon			P				P		
Excentrospheria									
BACILLARIOPHYCEAE									
Rhoicosphenia	P		P					P	
Meridion	P	P	P	P	P	P		P	P
Cyclotella	P	P							
Navicula	P	P	P		P	P	P	P	P

Reservoirs/ Parameters	Khari	Kothari	Orai	Gambhiri	Udaisagar	Nand-samand	Som Kamla Amba	West Benas	Jawai
Melosira	P	P			P				
Frustulia			P		P	P	P	P	P
Gyrosigma		P						P	P
Synedra	P	P	P	P	P	P	P	P	P
Diatoma	P		P			P	P	P	
Fragilaria					P		P		
Achnanthes			P		P				
Amphora					P		P		
Cymbella	P	P		P					
Amphipleura			P						
Nitzschia		P							
Caloneis					P				
Tabellaria	P	P	P	P	P	P	P	P	P
Coccoenis	P	P	P		P		P		P
Gomphonema									P
PROTOZOA									
Arcella	P				P		P	P	P
ROTIFERA									
Keratella	P	P	P	P	P	P	P	P	P
Polyarthra			P					P	
Brachionus	P	P	P	P	P	P	P	P	P
Filinia	P	P	P	P	P	P	P		
Notholca	P	P	P	P	P	P		P	P
Colurella		P		P		P		P	P

Reservoirs/ Parameters	Khari	Kothari	Orai	Gambhiri	Udaisagar	Nand-samand	Som Kamla Amba	West Benas	Jawai
Asplanchna	P	P	P		P				
Trichocerca		P	P	P		P		P	P
Monostyla							P		P
Haxarthra				P		P		P	
CLADOCERA									
Moina	P	P	P	P	P		P		P
Bosmina	P		P	P		P	P	P	P
Daphnia	P	P	P	P	P	P	P	P	P
Diaphanosoma	P	P	P	P	P		P	P	P
Chydrous	P		P		P		P		
Ceriodaphania									
COPEPODA									
Cyclops	P	P	P	P	P	P	P	P	P
Diaptomus	P	P	P	P	P	P	P	P	P

Table : 7 : Composition of macrobenthos in reservoirs of Rajasthan.

Groups	Chaoborus		Chironomids		Tubificids		Molluscs		Misc.		Total	
Reservoirs	u/m²	g/m²	u/m²	g/m²	u/m²	g/m²	u/m²	g/m²	u/m²	g/m²	u/m²	g/m²
Khari	150	0.18	483	1.26	-	-	150	neg.	-	-	783	1.44
Kothari	117	0.14	550	1.43	183	0.48	133	neg.	-	-	983	2.05
Orai	100	0.12	567	1.47	183	0.48	200	neg.	33	0.04	1083	2.11
Gambhiri	225	1.35	1150	14.95	150	1.95	150	0.55	-	-	1675	1.88
Udaisagar	250	0.30	2200	5.72	0	-	125	neg.	50	0.06	2625	6.08
Nand samand	200	1.20	667	8.66	+	-	183	neg.	100	1.00	1150	10.86
Som Kamla Amba	250	0.30	633	1.65	83	0.22	517	neg.	-	-	1483	2.17
West Benas	217	1.30	2250	29.25	-	-	217	neg.	-	-	2684	30.55
Jawai	50	0.30	133	1.73	34	0.43	133	neg.	-	-	350	2.46

Table : 8 : Macrophytes abundance (kg/m2) in reservoirs of Rajasthan.

Seasons	Pre-monsoon		Post-monsoon		Winter		Average	
Reservoirs	**Wet. wt.**	**Dry wt.**	**Wet. wt.**	**Dry wt.**	**Wet. wt.**	**Dry wt.**	**Wet. wt.**	**Dry wt.**
Khari	1.50	0.20	0.40	0.005	0.60	0.04	0.833	0.082
Kothari	0.90	0.15	Nil	-	0.72	0.012	0.540	0.054
Orai	Nil	-	Nil	-	0.24	0.003	0.080	0.001
Gambhiri	Nil	-	Nil	-	Nil	-	Nil	-
Udaisagar	Nil	-	Nil	-	Nil	-	Nil	-
Nandsamand	1.50	0.080	0.800	0.040	Nil	-	0.767	0.040
Som Kamla Amba	0.60	0.08	0.60	0.01	Nil	-	0.40	0.03
West Benas	Nil	-	Nil	-	Nil	-	Nil	-
Jawai	Nil	-	Nil	-	Nil	-	Nil	-

Table : 9 : Stocking (fry in lakhs) in reservoirs of Rajasthan.

Years/Reservoirs	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	Average/ha
Khari	6.55	1.00	1.25	20.0	0.95	8.00	0.01356
Kothari	6.70	0.80	4.50	9.00	3.66	18.00	0.01509
Orai	1.10	0.75	3.75	Nil	Nil	11.00	0.00720
Udaisagar	1.45	2.95	0.163	3.485	Nil	Nil	0.00508
Som Kamla Amba	-	-	-	-	60.0	61.0	0.01672

Years/Reservoirs	1996-97	1007-98	1998-99	1999-2000	2000-01	2001-02	Average/ha
Jawai	16.00	56.76	49.0	10.94	26.70	45.88	0.02200
West Benas	6.75	1.0	Nil	2.75	5.00	7.00	0.00517
Nandsamand	1.50	Nil	Nil	0.55	5.00	3.00	0.00686
Gambhiri	2.75	0.45	10.00	2.90	32.0	18.75	0.00794

Table :10 : Catch composition (t) in reservoirs of Rajasthan.

Reservoirs	Khari		Kothari		Orai		Udaisagar		Som Kamla Amba	
Groups/years	1999-2k	2k-01	1999-2k	2k-01	1999-2k	2k-01	1999-2k	2k-01	1999-2k	2k-01
IMC	-	7.11	10.955	3.515	14.075	23.7	8.17	-	20.0	23.8
Cat fishes	-	2.59	4.070	2.215	4.920	11.2	5.38	-	10.0	4.2
Minor carps	-	2.29	6.271	1.275	6.505	12.0	31.95	-	20.0	14.0
Total	Nil	11.99	21.296	7.005	25.400	46.9	45.50	Nil	50.0	42.0
Kg/ha	-	25.8	54.2	14.9	66.1	122.1	172.3	-	23.0	19.4

Reservoirs	Jawai		West Benas		Nandsamand		Gambhiri	
Groups/Years	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
IMC	-	100.662	93.630	79.877	3.350	14.124	22.7	51.0
Cat fishes	-	4.918	27.345	12.393	1.260	3.972	10.6	-
Minor carps	-	11.899	31.994	13.717	22.630	20.808	10.7	10.7
Misc.	-	8.705	-	-	-	-	2.3	16.1
Total	Nil	126.184	152.969	105.987	27.240	38.904	46.3	77.8
Kg/ha	-	97.0	271.0	188.0	111.6	160.0	33.0	55.5

Fig. 2a - Composition of plankton in Khari Reservoir of Rajasthan.

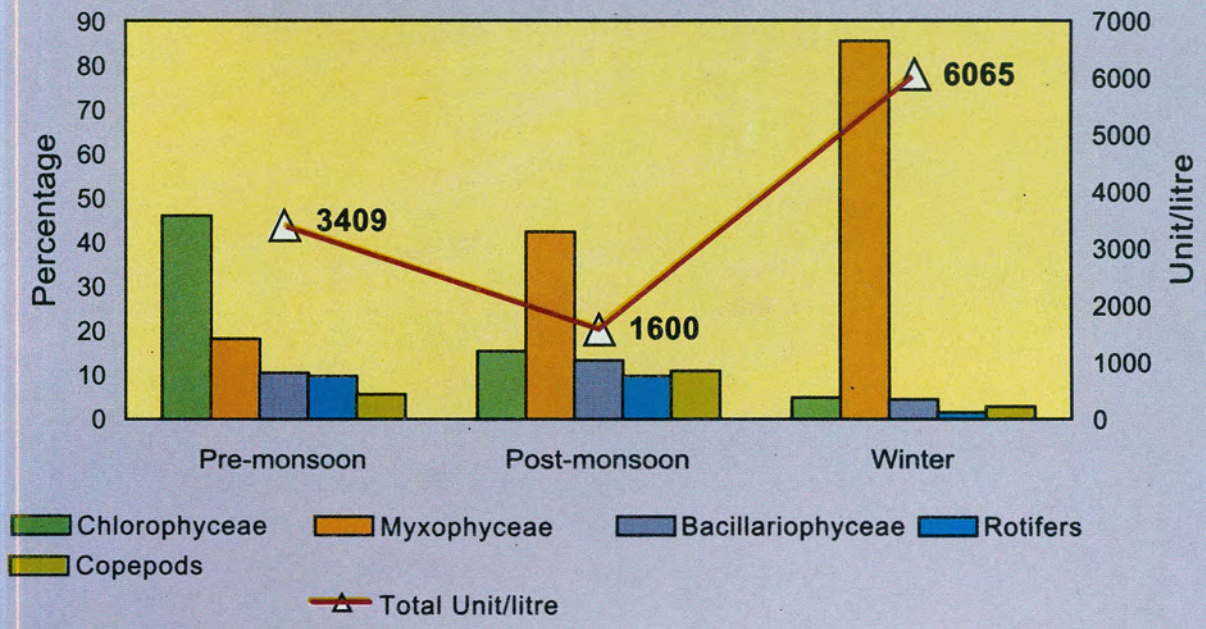


Fig. 2b - Composition of plankton in Kothari reservoir of Rajasthan.

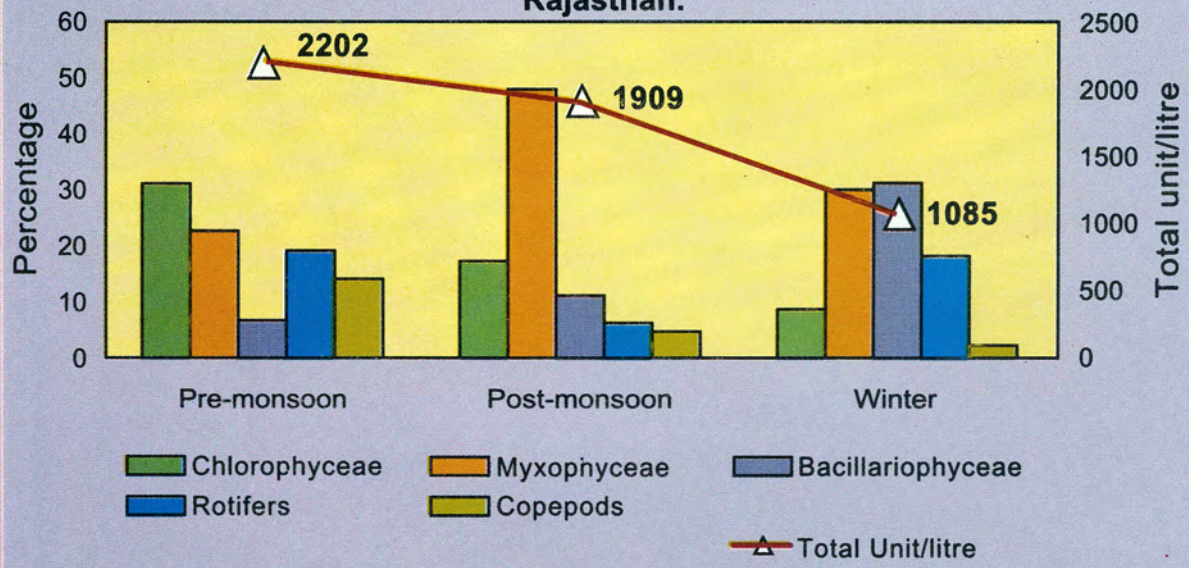


Fig. 2c - Composition of plankton in Orai reservoir of Rajasthan.

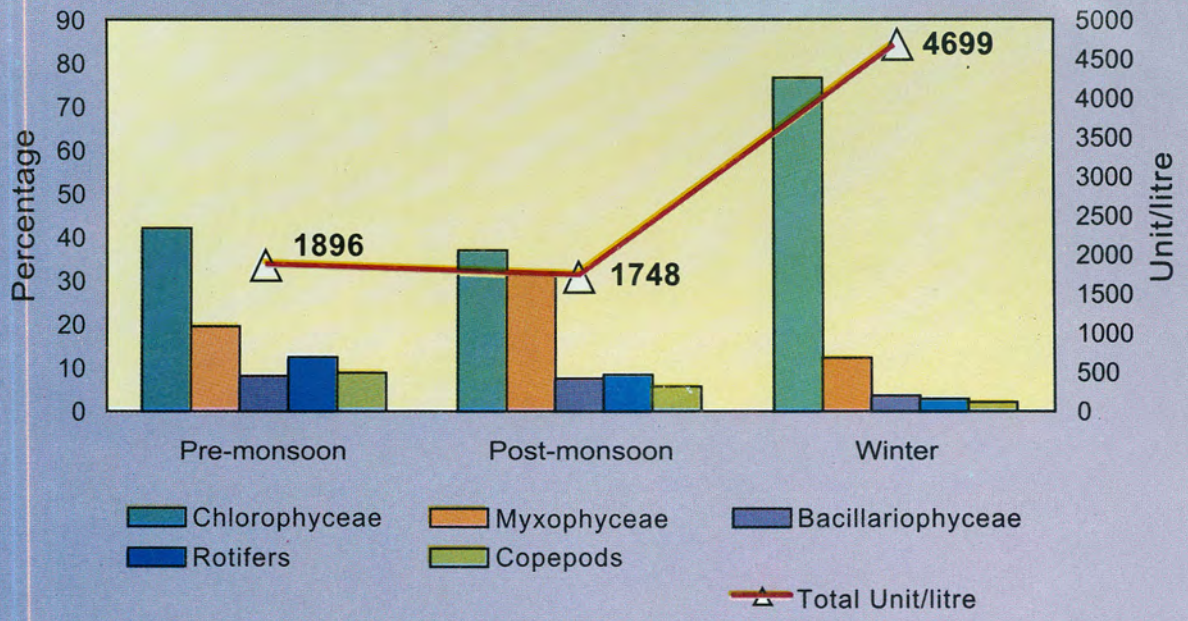


Fig. 2e - Composition of plankton in Udaisagar reservoir of Rajasthan.

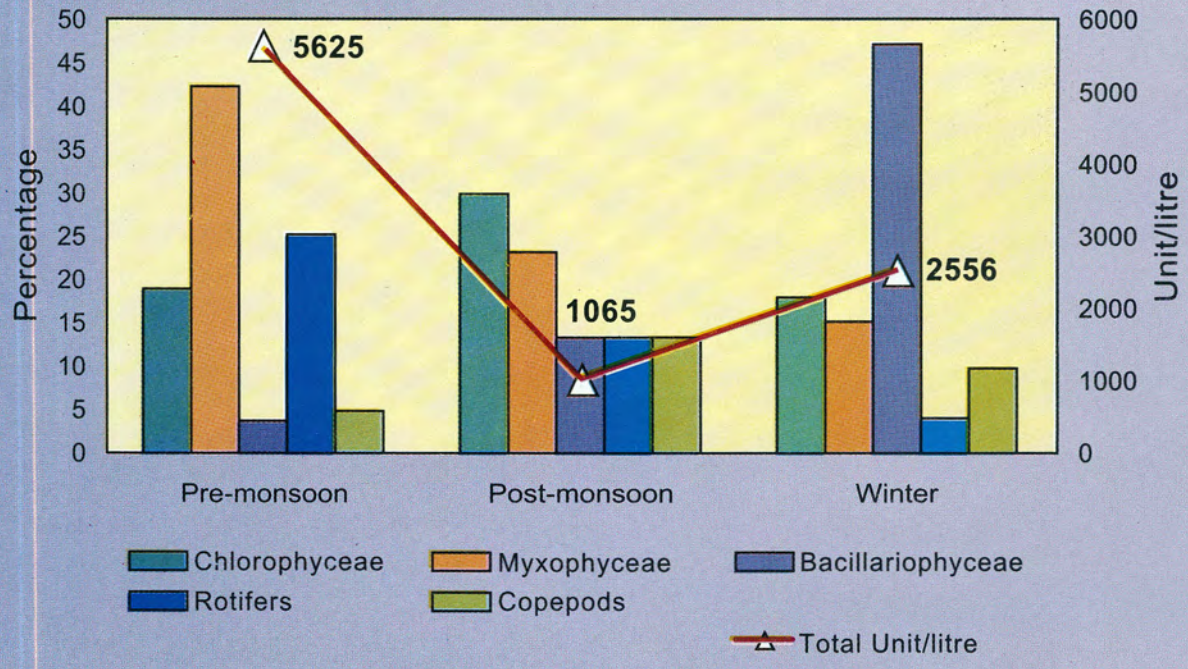


Fig. 2f - Composition of Plankton in Nandsamand reservoir of Rajasthan.

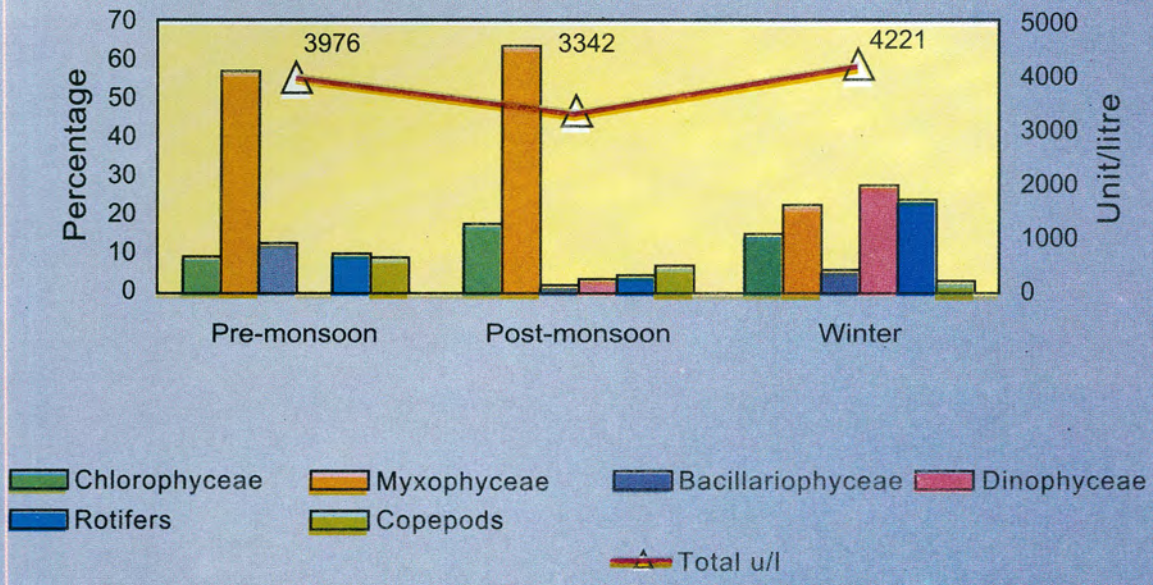


Fig. 2d - Composition of plankton in Gambhiri reservoir of Rajasthan.

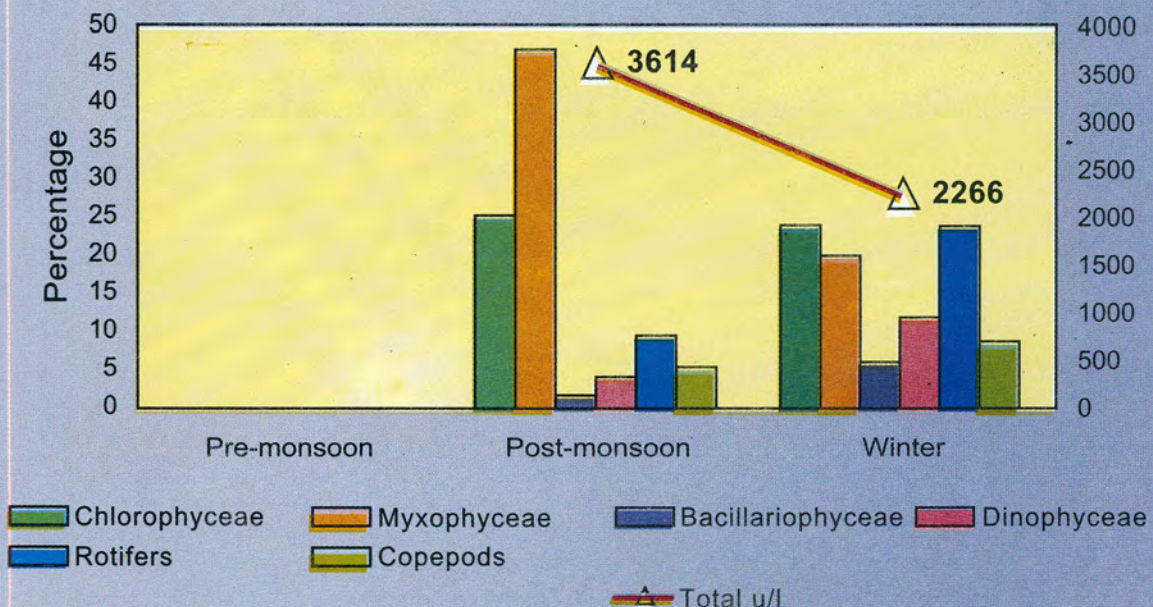


Fig. 2g - Composition of plankton in Som Kamla Amba reservoir of Rajasthan.

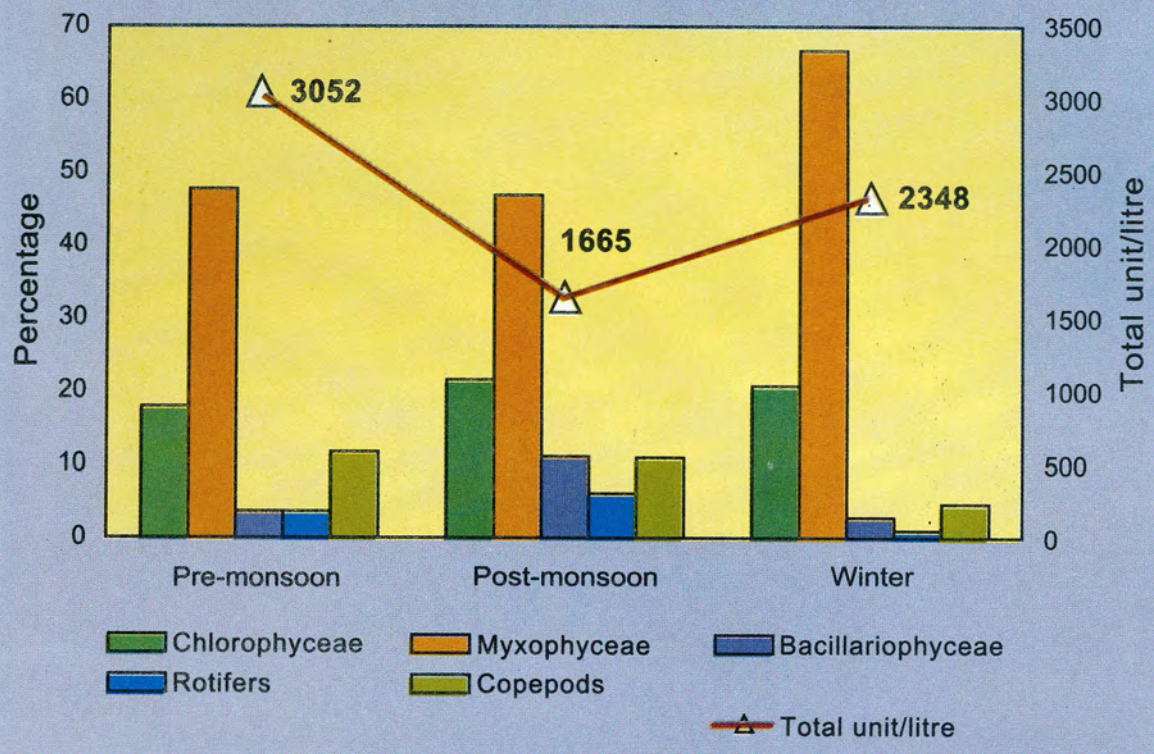


Fig.2i - Plankton composition in Jawai reservoir of Rajasthan.

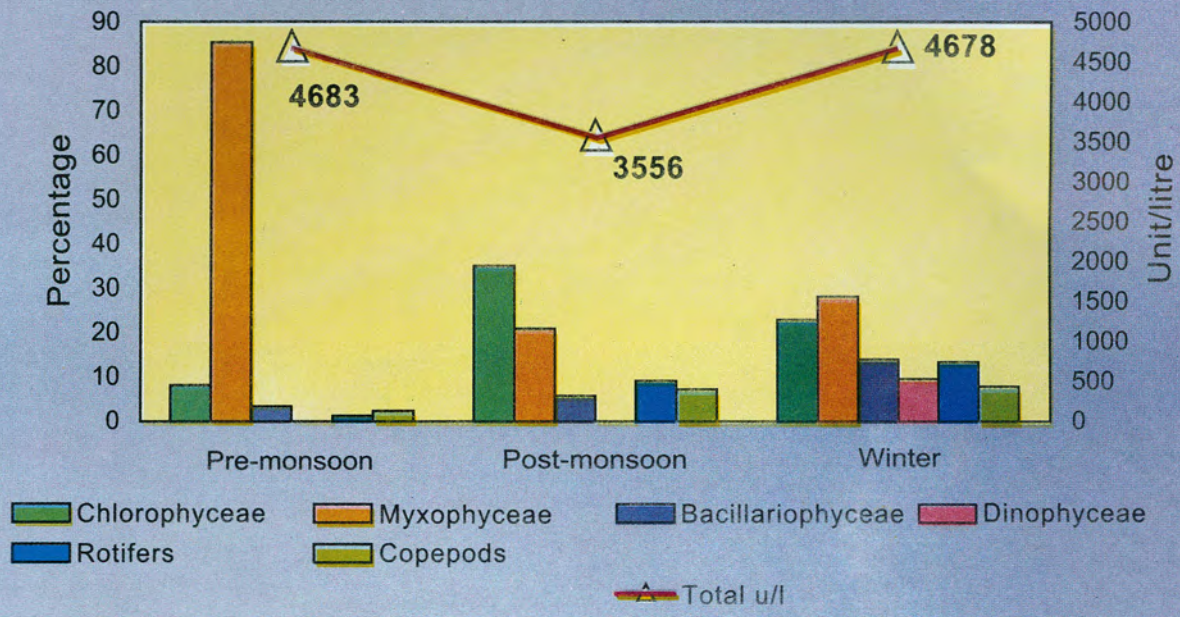


Fig. 2h - Composition of plankton in West Benas Reservoir of Rajasthan.

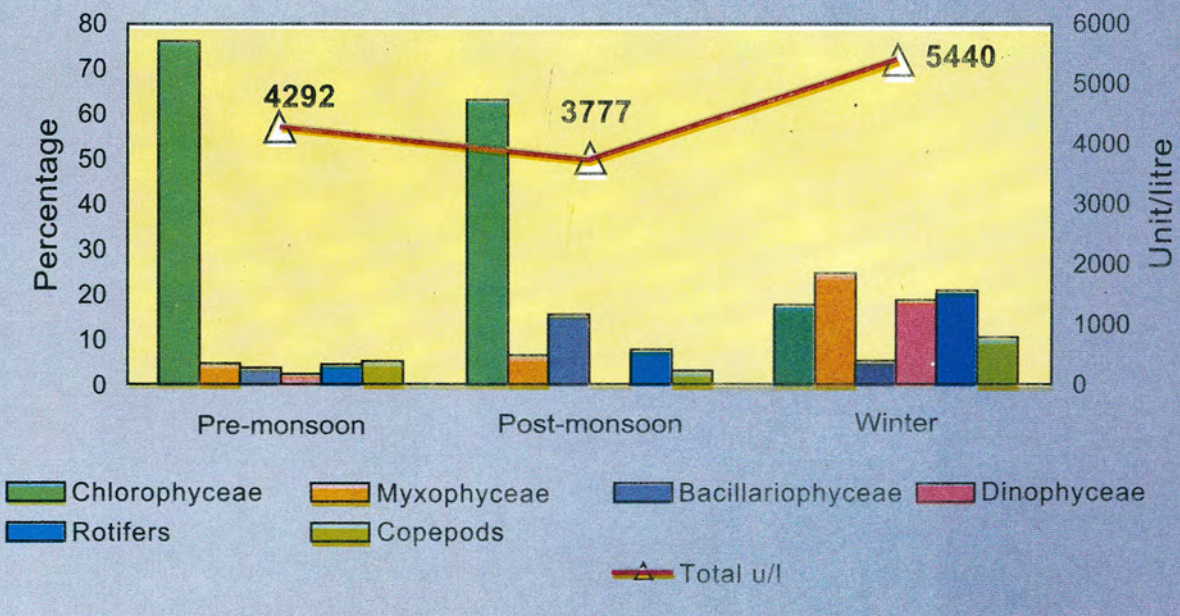


Fig. 3a- Composition of periphyton in Khari reservoir of Rajasthan.

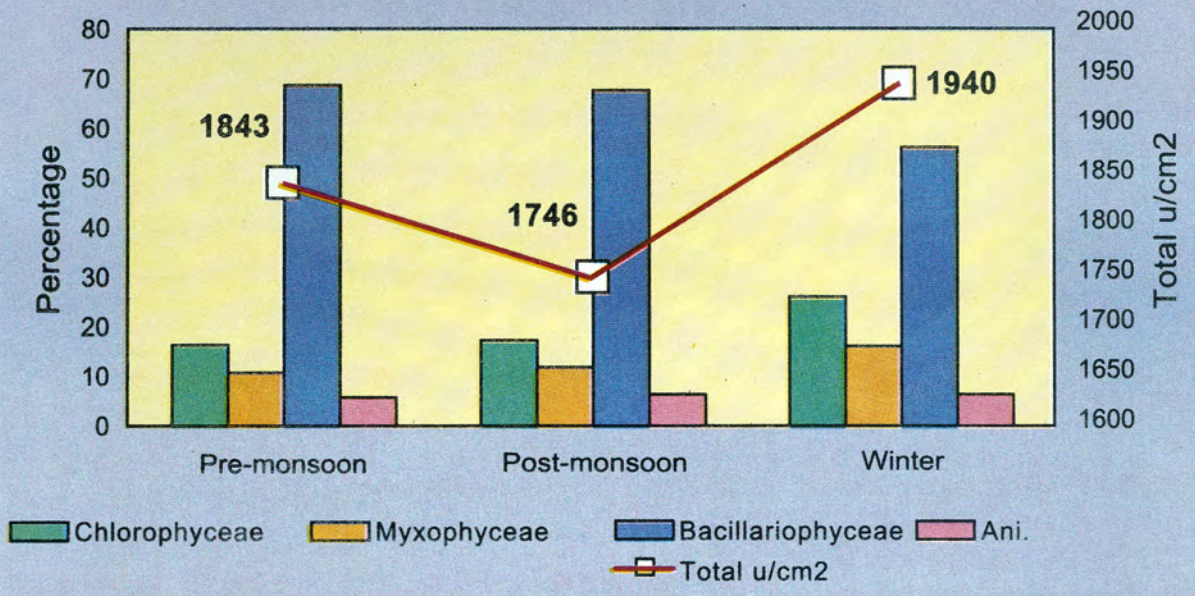


Fig. 3b-Composition of periphyton in Kothari reservoir of Rajasthan.

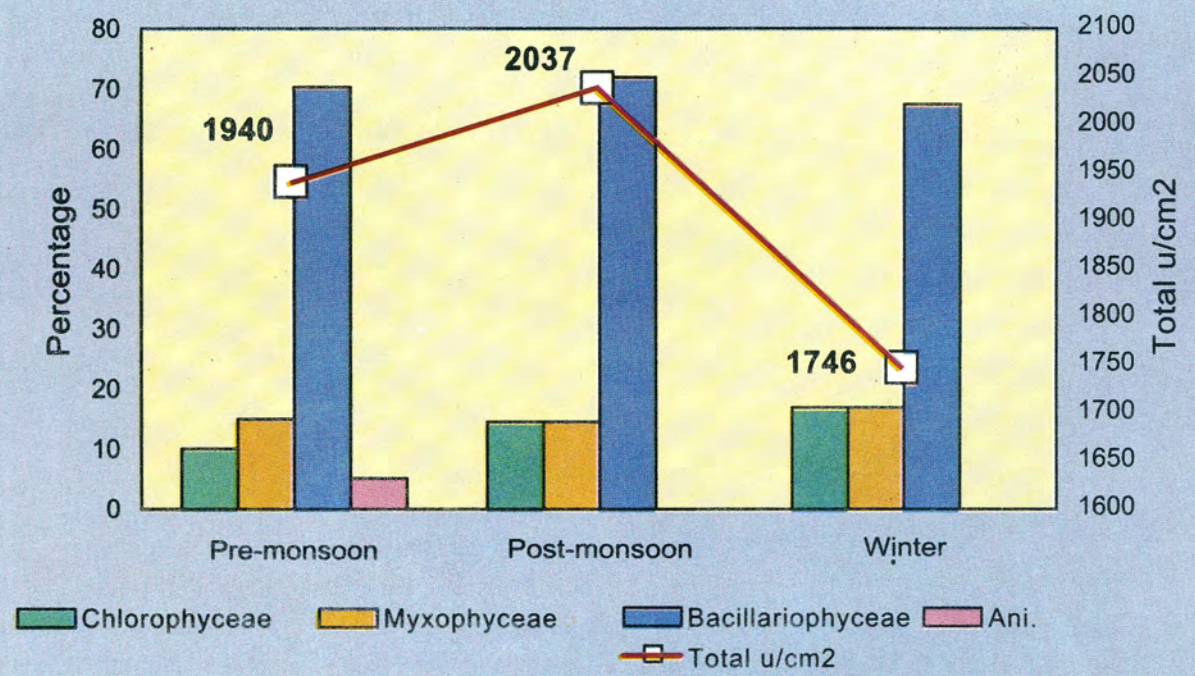


Fig. 3c-Composition of periphyton in Orai reservoir of Rajasthan.

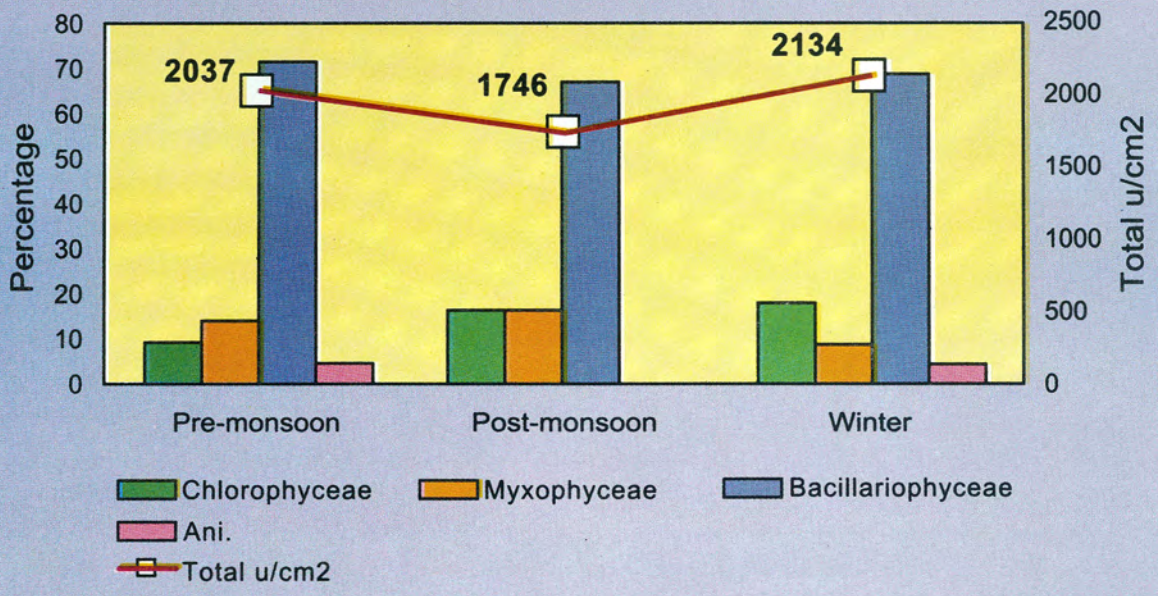


Fig. 3e-Composition of periphyton in Udaisagar reservoir of Rajasthan.

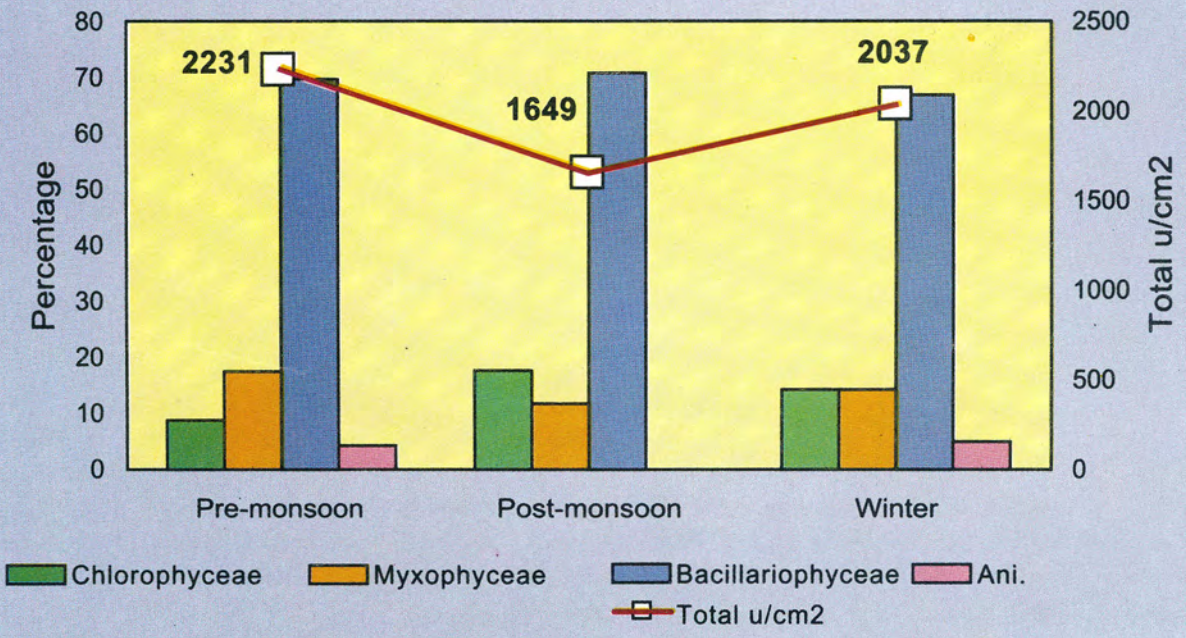


Fig. 3f -Composition of periphyton in Nandsamand reservoir of Rajasthan.

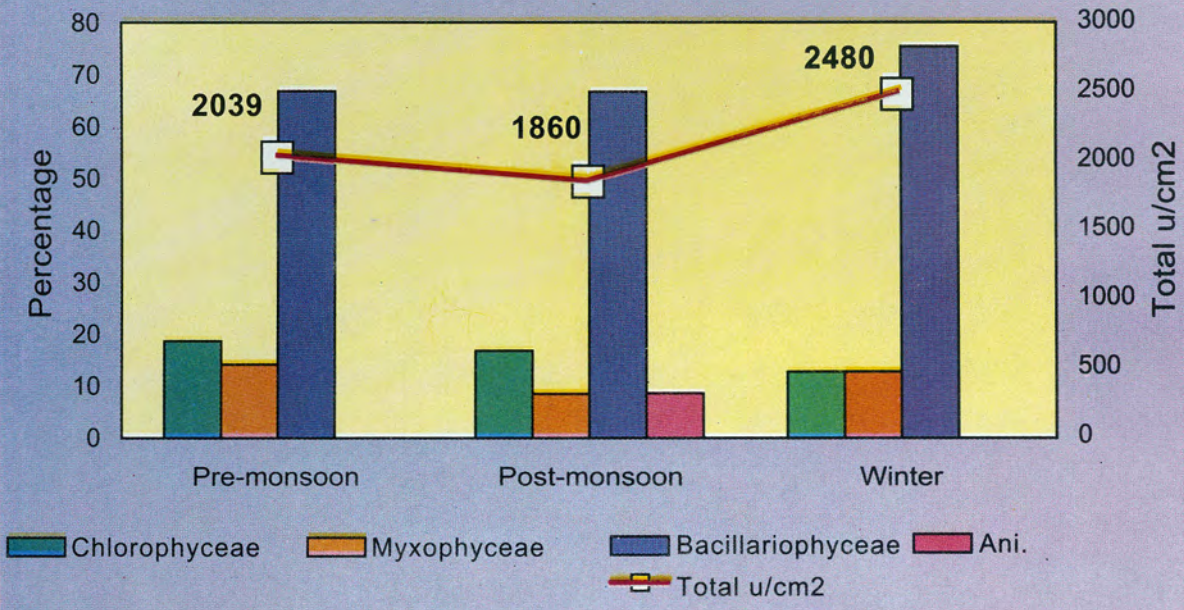


Fig. 3d - Composition of periphyton in Gambhiri reservoir of Rajasthan.

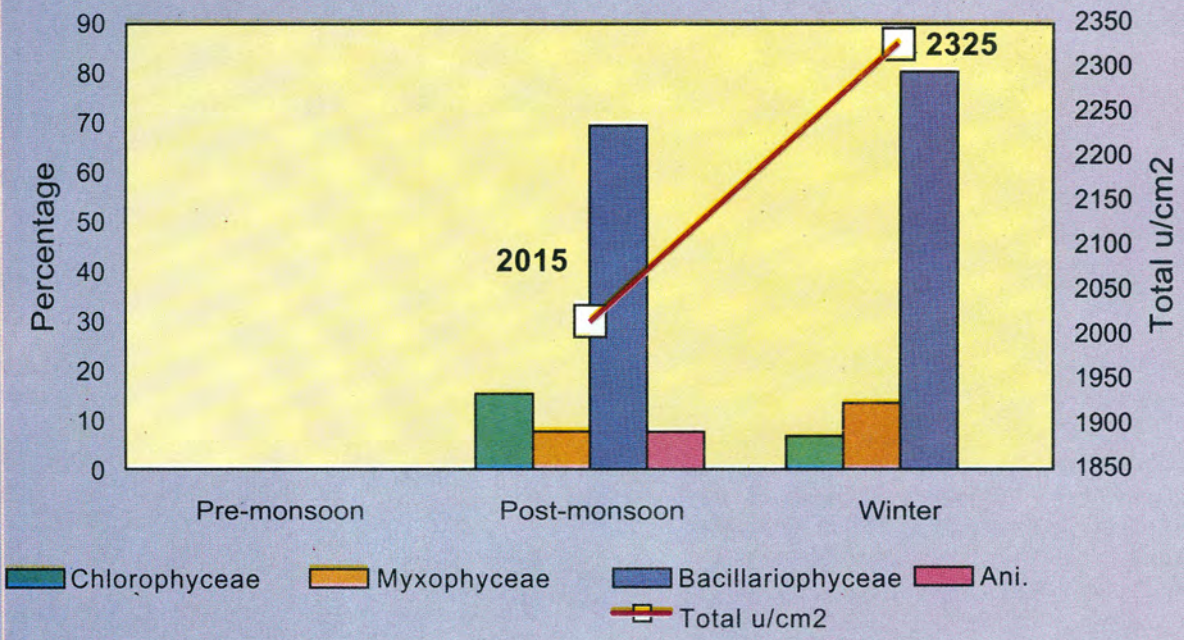


Fig. 3g-Composition of periphyton in Som Kamla Amba reservoir of Rajasthan.

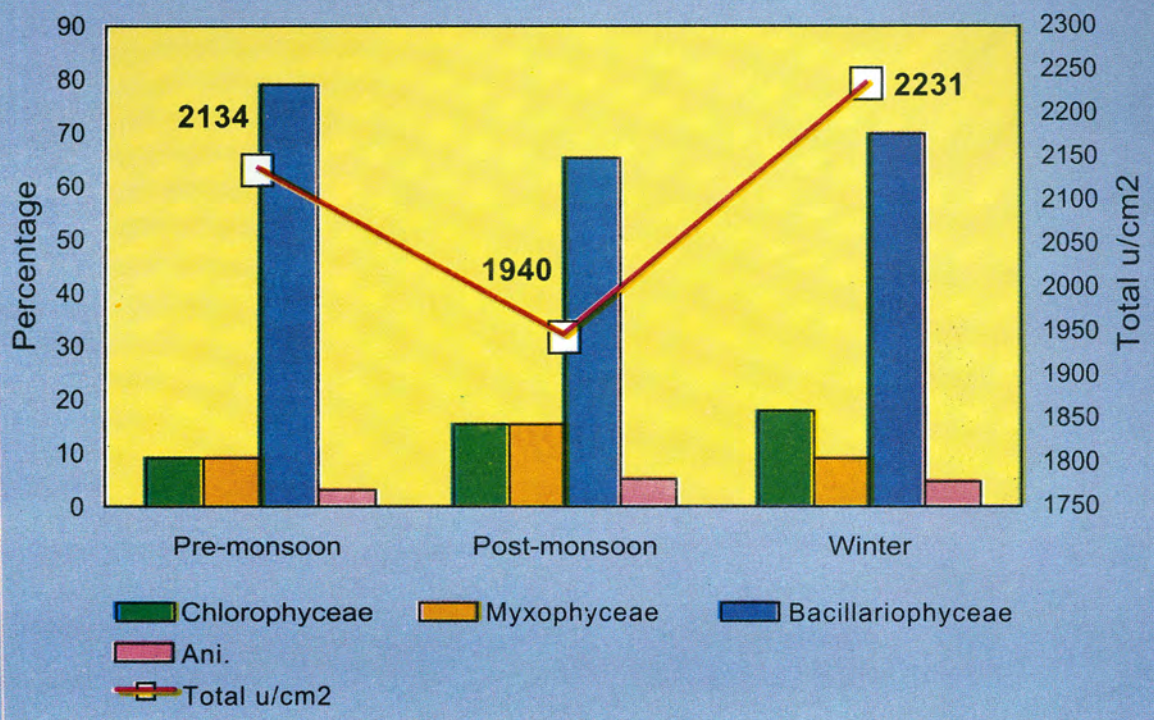


Fig. 3i- Composition of periphyton in Jawai reservoir of Rajasthan.

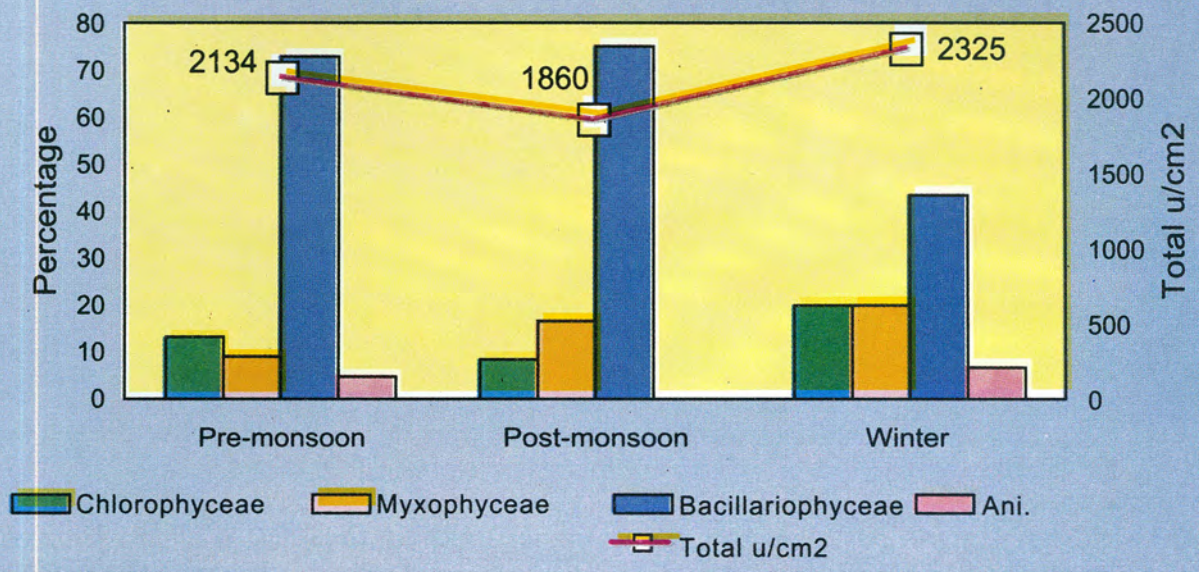
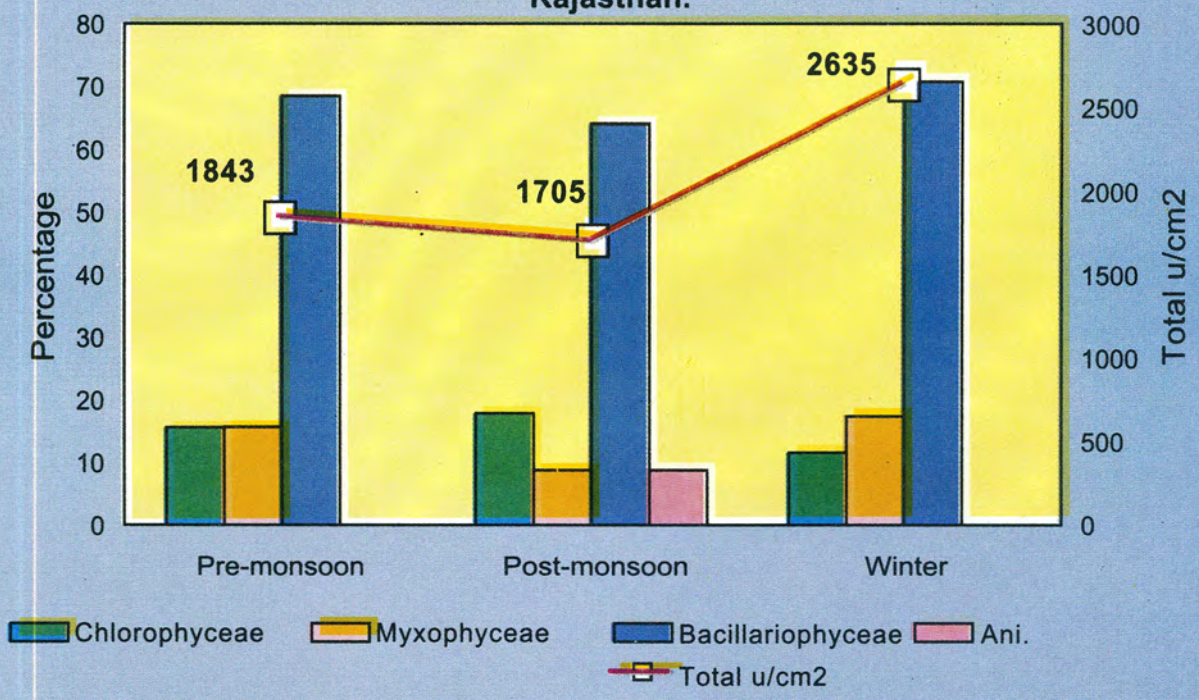


Fig. 3h- Composition of periphyton in West Benas reservoir of Rajasthan.

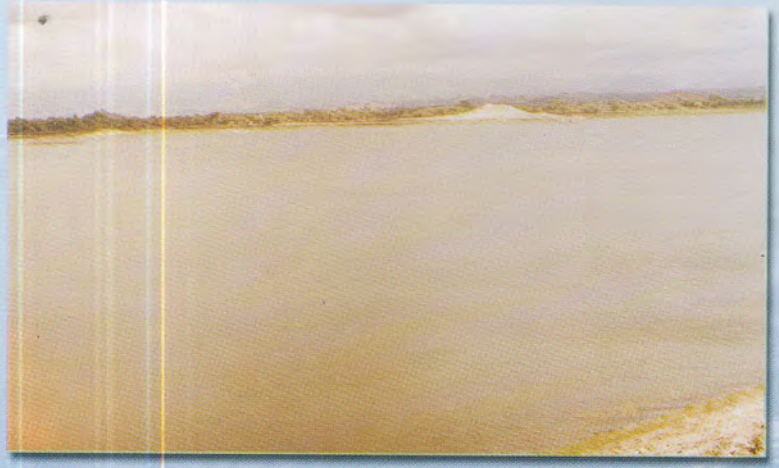


View of Kothari Reservoir

View of Khari Reservoir

View of Nand samand Reservoir

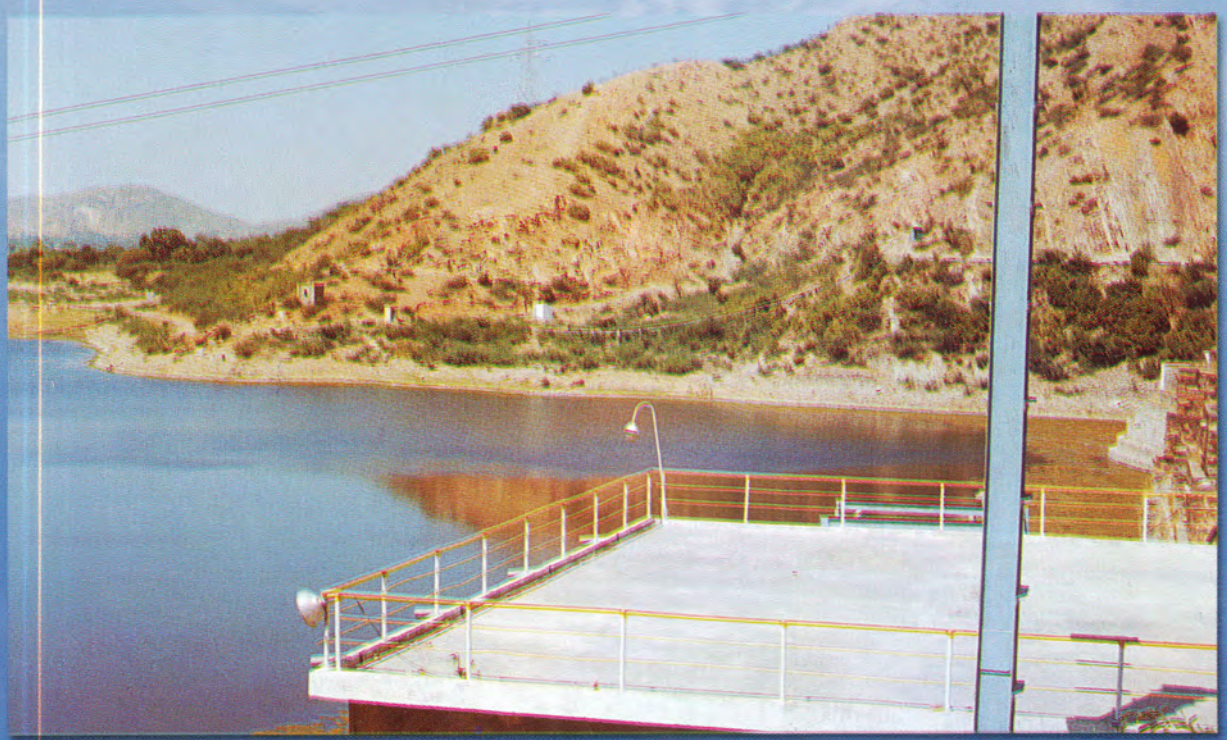
View of Orai Reservoir



View of West benas Reservoir

Fish catch at Orai Reservoir

View of Gambhiri Reservoir



View of Udai sagar Reservoir

View of Jawai Reservoir

View of Som kamla amba Reservoir