ECOLOGY-BASED FISHERIES MANAGEMENT IN SOME RESERVOIRS OF EASTERN RAJASTHAN

Central Inland Capture Fisheries Research Institute

Ecology-based fisheries management in some reservoirs of Eastern Rajasthan

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FOREWORD

Reservoir or man-made lake has a special role to play in the development of the country's inland fish production. An estimate puts the reservoir fishery resource of India to over 3 million ha. Evidently, even a modest hike in yield rate from this resource can add substantially the inland fish production of the country. A number of impoundments in recent years have been created in the country for hydel generation, irrigation, flood control and other water-oriented activities. Reservoirs thus created are unique biome wherein rich and diverse aquatic biodiversity exists due to prevalence of lotic as well as lentic aquatic regimes. Management of reservoir fishery has assumed enormus 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 thus has greater relevance in developing countries like India as it has termendous scope for yield enhancement besides being more labour incentive and eco-friendly in nature.

For assessing the fishery potential, it is expedient to undertake the qualitative and quantitative assessment of the limno-chemical and biotic variables. Keeping this aspect in view CICFRI initiated investigations on the ecology and fisheries of reservoirs situated in different states of India. As part of this study, scientists of CICFRI surveyed reservoirs of Eastern Rajasthan for three years and this publication is a documentation of the research data generated during the investigation. I am hopeful that this document will greatly help in formulating guidelines for scientific management, not of the said reservoirs alone but also for other similar water bodies available in the region.

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

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Contents

1. INTRODUCTION

India has been endowed with vast reservoir resource due to creation of large number of impoundments in the country for harnessing river water for industrial, agricultural and domestic purposes, power generation, flood controls and for other water oriented activities. Presently, the country has over 3 million hectares of water area under reservoirs . These man made lakes are unique ecosystems due to the synthesis of both lentic and lotic ecological regimes and have attracted the attention of the limnologists and fishery managers alike to understand their ecology and to harness their biotic potential for the welfare of mankind. The current level of fish yield from Indian reservoir is very low, averaging about 20 kg/ha/yr (Sugunan,1995). These under utilised fisheries resources offer immense scope and potential for generating additional national income estimated to be of the order of Rs. 1000 million per year by the implementation of managerial measures on scientific lines.

Impoundment of river and the resultant creation of a new reservoir radically alter the hydrology of river, both up and down stream. The quality of impounded water is dependent on the shape of reservoir basin, exposure to light and wind action and the rate of water exchange. The evaluation of specifics of water quality is therefore essential for reservoirs sharing the same eco-climatic conditions.

Rajasthan has about 3.0 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 falls 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 reservoirs are located. A large number of small impoundments have been created in the Aravalli region too, especially in the districts of Pali, Udaipur and Sirohi. The southern region of the state consisting the districts of Banswara, Chittorgarh, Rajsamand, Jhalawara and Kota has maximum number of man-made lakes. The four large reservoirs viz., Rana Pratapsagar (19600 ha , Chittorgarh district), Mahi Bajajsagar (13500 ha, Banswara district), Kadana (9000 ha, Banswara and Dungarpur districts) and Jaisamand (7600 ha, Udaipur district), cover more than 32% of the total reservoir area. Among the 423 listed reservoirs, only four are in the large category, while the small and medium reservoir number are 389 and 30 respectively.

Management practices with proper stock manipulation by adopting a judicious exploitation-cum -stocking policy are the keys for hike in productivity of a reservoir. Taking a queue from this concept, the present study was carried out to evolve management plans capable of enhancing fish productions in small and medium reservoirs of Eastern Rajasthan.This report portrays the significant findings of the ecological investigations of selected reservoirs (Fig. 1) namely Sainthal, Kalakho, Morel, Galwa, Mavshi, Guda Mansarovar, Silished, Panchna and Baretha in the Eastern Rajasthan.

2. SAMPLING PROCEDURE

Samples pertaining to limnological parameters were collected from Sainthal and Kalakho reservoirs once in post-monsoon (September,1997), winter (January,1998) and summer (June,1998) seasons. Similarly, seasonal changes in the Morel, Galwa, Panchna and Baretha reservoirs of Eastern Rajasthan were investigated in the year 1998-99. Mavshi, Guda, Mansarovar and Silished reservoirs were studied in the year 1999-2000. The physico-chemical parameters of water were determined following the standard method given in APHA (1989). The collection and analyses of biological parameters were done as described by Jhingran *et al.*, (1969).


Ganganagar
Bikaner
Churu
Jhunjhunu
Sikar
Alwar
Bharatpur
Jaisalmer
Nagaur
Jodhpur
Jaipur
Dausa
Karoli
Dholpur
Ajmer
Tonk
Barmer
Pali
Bhilwara
Bundi
Jalore
Barana
Rajsamand
Sirohi
Kota
Udaipur
Jhalwara
Dungarpur
Chittorgarh
Banswara

3. SAINTHAL RESERVOIR

3.1 Location :- Sainthal reservoir is located at latitude 27^0-2'N near village Baroda across the river Sawa. It lies in Banganga river basin in the Dausa district of Eastern Rajasthan (Fig. 2). It is a century old shallow reservoir constructed for irrigation purposes in the year 1898.

3.2 Morphometry :- The reservoir has a water spread area of 520 ha at FRL and a catchment area of 305 km^2. It falls under the small reservoir category. The low mean depth of 2.64 m indicate shallowness of the reservoir. The other salient features of morphometry are presented in Table 1.

3.3 Meteorological observations :- The atmospheric temperature varied from 22°C in winter to 36°C in post-monoon. The average rainfall in the area is 66.0 cm.

3.4 Limnology and Productivity :-

i) Physico-chemical characteristics of soil :- The basin soil was sandy loam in texture (Table 2) . Soil pH was near neutral (6.8). Organic carbon (0.3%) and available phosphorus (4.0 mg/100g) were poor whereas available nitrogen (42.5 mg/100g) was in moderate range.

ii) Physico-chemical characteristics of water :- The water temperature was lowest in winter (17°C) while it was highest in post-monsoon (32°C) period , Table 3. The water is alkaline (pH 7.8) which enable the normal ion exchange of fresh water fishes and is favourable for fish growth. Transparency fluctuated from 38 in post-monsoon to 136 cm in winter. The higher values in winter were probably due to low wind turbulence. Dissolved oxygen ranged from 6.4 to 9.6 (av. 7.7) ppm. Free CO_2 was absent during all the seasons. The seasonal variation in total alkalinity was quite discernible with minimum values in winter (66.0 ppm; Table 3) and maximum in summer (184.0 ppm). The water bodies having total alkalinity above 90.0 ppm are generally conducive to high fish productivity.

VIEW OF SAINTHAL RESERVOIR

Table :1 : Morphometric features of reservoirs of Rajasthan.

Parameters	Sainthal	Kalakho	Morel	Galwa	Mavshi	Guda	Mansarovar	Silished	Panchana	Baretha
Location										
i) Latitude N	27^0-2'	26^0-54'	26^0-26'	25^0-31'	26^0-25'	25^0-56'	25^0-26'	27^0-3'	26^0-33'	-
ii) Longitude N	76-17'	76-28'	76^0-20'	75^0-48'	75^0-48'	75^0-28'	76^0-26'	-	77^0-0'	-
iii) District	Dausa	Dausa	Dausa	Tonk	Tonk	Bundi	S.Madhopur	Alwar	Karoli	Bharatpur
Year of impoundment	1898	1953	1952	1960	1960	1958	1952	1845	-	-
Area (ha) at F.R.L.	520	724	1564	1800	1600	1859	306	275	1240	1006
Av. (60%)) Area (ha)	312	434	938	1080	960	1115	184	165	744	604
Catchment Area (km^2)	305	1390	3346	380	5575	744.9	35	136.7	621.6	181
Catchment Reservoir Area	58.6	18.5	213.9	21	348.0	40.0	11.4	49.7	50	18
Mean Depth (m)	2.6	1.8	4.9	2.7	3.0	5.1	5.0	5.06	4.8	5.2
Gross storage Capacity (million m^3)	13.75	13.28	77.6	48.7	48.14	95.66	15.31	13.93	59.45	52.66
Live storage Capacity (million m^3)	12.08	10.82	70.7	47.2	24.05	93.68	14.00	-	52.65	50.68

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

Parameters	Sainthal	Kalakho	Morel	Galwa	Mavshi	Guda	Mansarovar	Silished	Panchana	Baretha
Sand (%)	63.5	45.2	71.6	69.6	35.3	32.8	50.4	49.7	69.1	69.5
Silt (%)	18.7	30.2	17.1	16.9	62.4	30.7	45.9	46.0	18.3	14.7
Clay (%)	17.8	24.6	11.3	13.5	2.3	36.5	3.7	4.3	12.6	15.8
pH	6.8	6.9	7.0	7.0	8.0	7.8	7.5	7.8	7.1	7.0
Organic carbon (%)	0.30	0.29	0.33	0.33	0.34	0.26	0.26	0.28	0.39	0.46
C_aCO_3 (%)	1.25	1.38	1.80	1.75	7.8	9.9	6.7	5.2	1.62	1.54
Av. Phosphorus (mg/100g)	4.0	4.1	3.1	2.3	3.0	3.6	2.5	3.2	2.45	2.50
Av. Nitrogen (mg/100g)	42.5	47.6	43.2	38.4	39.3	49.9	40.5	42.5	41.9	45.2
Sp. conductivity (μmhos/cm)	263.2	239.6	262.4	238.6	419.0	895.0	528.0	522.0	213.6	271.0

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

Parameters	Sainthal	Kalakho	Morel	Galwa	Mavshi	Guda	M.sarovar	Silished	Panchana	Baretha
Water temp. (0C)	27 (17-32)	26 (17-32)	28 (21-34)	28 (20-35)	25 (18-31)	24 (16-30)	24 (16-30)	22 (15-29)	28 (19-33)	27 (17-35)
Transparency (cm)	94 (38-136)	57 (23-81)	61 (26-86)	54 (18-72)	34 (26-42)	72 (41-97)	85 (71-100)	32 (16-61)	73 (46-95)	105 (44-105)
pH	7.8 (7.3-8.6)	7.8 (7.3-8.2)	7.3 (6.8-8.2)	7.5 (6.8-8.3)	8.4 (7.2-9.2)	8.0 (7.7-8.3)	7.9 (7.8-8.1)	8.1 (7.6-8.9)	7.7 (7.4-8.2)	7.6 (7.4-7.8)
D.O. (ppm)	7.7 (6.4-9.6)	8.8 (6.8-11.4)	8.9 (6.8-10.4)	8.5 (7.2-9.6)	7.9 (5.6-9.2)	7.3 (5.6-9.2)	8.3 (4.8-11.2)	8.0 (4.8-10.0)	9.3 (6.0-12.8)	10.2 (8.8-12.0)
Free CO_2	Nil	Nil	1.3 (Nil-4.0)	3.7 (Nil-11.2)	Nil	Nil	Nil	Nil	1.4 (Nil-4.0)	3.8 (02-6.4)
Total alkalinity (ppm)	127 (66-184)	123 (50-196)	181 (124-250)	199 (170-256)	106 (70-154)	89 (72-146)	89 (40-136)	84 (70-110)	135 (122-150)	125 (100-146)
Sp. cond.(µmhos/cm)	432 (336-567)	231 (142-330)	649 (328-959)	225 (180-336)	946 (774-1170)	306 (197-426)	236 (178-319)	392 (330-510)	201 (161-237)	197 (108-291)
TDS (ppm)	215 (167-282)	118 (80-165)	325 (164-480)	113 (80-167)	471 (383-585)	152 (98-212)	118 (89-160)	196 (164-256)	103 (80-118)	98 (54-146)
Hardness (ppm)	76 (40-108)	84 (52-100)	77 (52-104)	117 (86-140)	159 (130-208)	132 (92-160)	176 (97-284)	198 (140-284)	93 (78-104)	103 (92-112)
Calcium (ppm)	18.7 (14.4-22.4)	17.6 (12.8-20.8)	26.7 (19.5-32.0)	32.4 (20.1-44.9)	19.5 (18.0-21.0)	32.0 (25.0-39.0)	29.5 (22.0-37.0)	32,5 (23.0-42.0)	28.7 (22.1-32.0)	30.1 (26.3-35.3)
Magnesium (ppm)	12.2 (7.9-17.7)	16.3 (11.8-24.2)	6.6 (1.2-10.8)	6.3 (1.4-10.8)	20.7 (18.6-22.8)	9.3 (7.2-11.4)	11.4 (10.2-12.6)	17.7 (15.6-19.8)	3.8 (1.6-5.8)	5.2 (1.9-7.9)
DOM (ppm)	4.4 (2.6-5.6)	4.4 (1.8-5.8)	2.9 (1.4-5.2)	3.3 (1.6-6.4)	5.6 (2.5-8.4)	5.2 (1.5-9.6)	6.0 (2.4-9.6)	7.6 (6.4-11.6)	2.7 (1.0-5.6)	3.0 (1.2-6.0)
Phosphate (ppm)	0.02 (0.02-0.03)	0.01 (0.01-0.02)	0.04 (0.01-0.08)	0.07 (0.02-0.12)	0.02	0.02	0.04 (0.02-0.06)	0.03 (0.02-0.04)	0.05 (0.01-0.06)	0.08 (0.03-0.12)
Silicate (ppm)	1.4 ( )	1.2 (1.2-1.3)	1.8 (1.7-2.1)	2.0 (1.7-2.4)	2.2 (2.0-2.4)	2.3 (2.0-2.6)	3.3 (3.2-3.4)	3.8 (3.2-3.4)	1.4 (1.4-1.5)	1.8 (1.6-2.0)
Chloride (ppm)	22.1 (19.8-23.8)	24.9 (19.9-34.0)	42.0 (9.7-69.6)	32.4 (12.8-47.0)	66.7 (39.7-119.3)	7.7 (5.6-11.3)	6.0 (2.8-11.3)	11.9 (8.5-17.0)	17.8 (11.7-23.3)	16.0 (9.7-19.9)

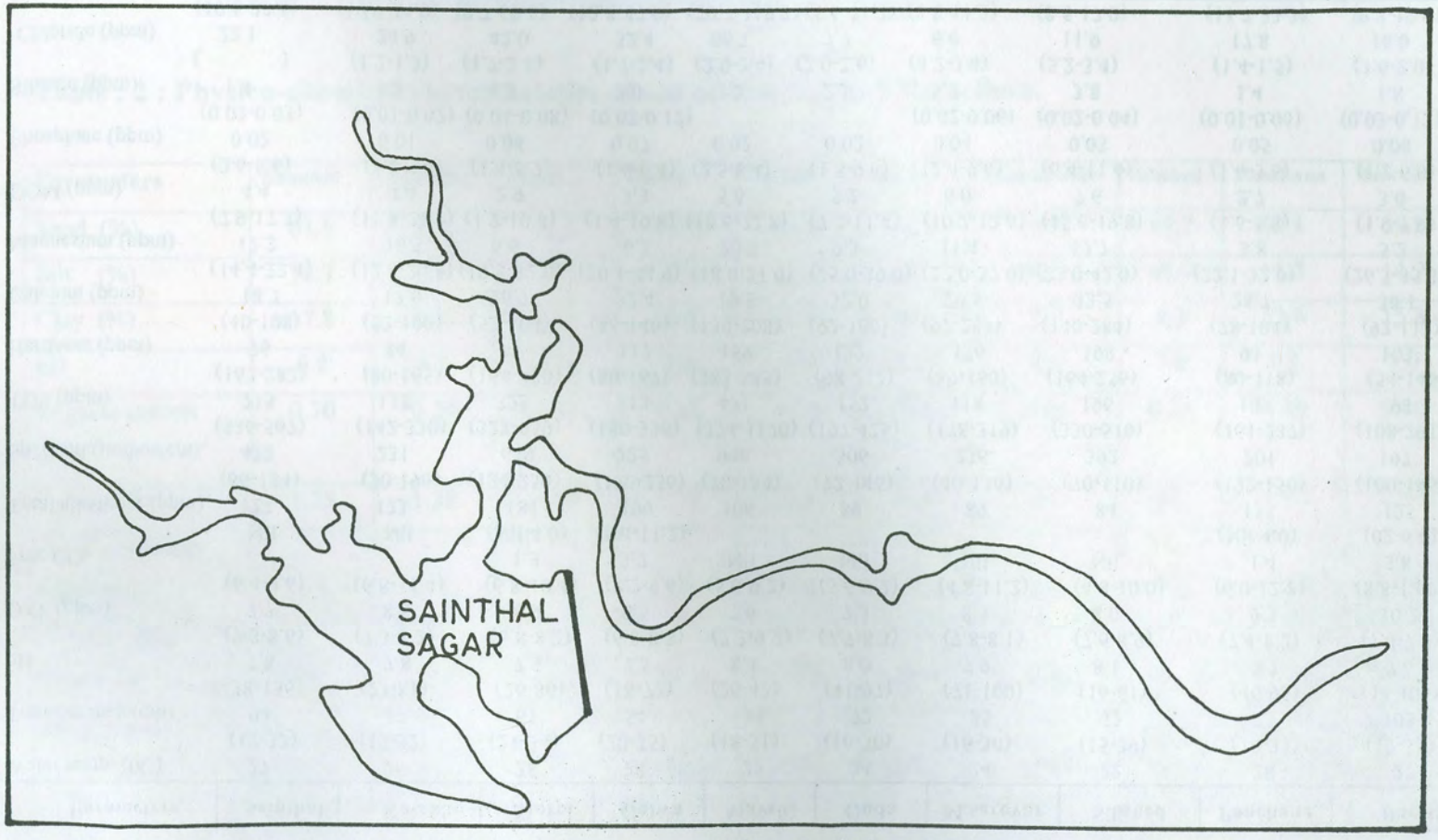


FIG.2- SCHEMATIC VIEW OF SAINTHAL RESERVOIR

Fig.3 : Primary production in Reservoirs of Rajasthan

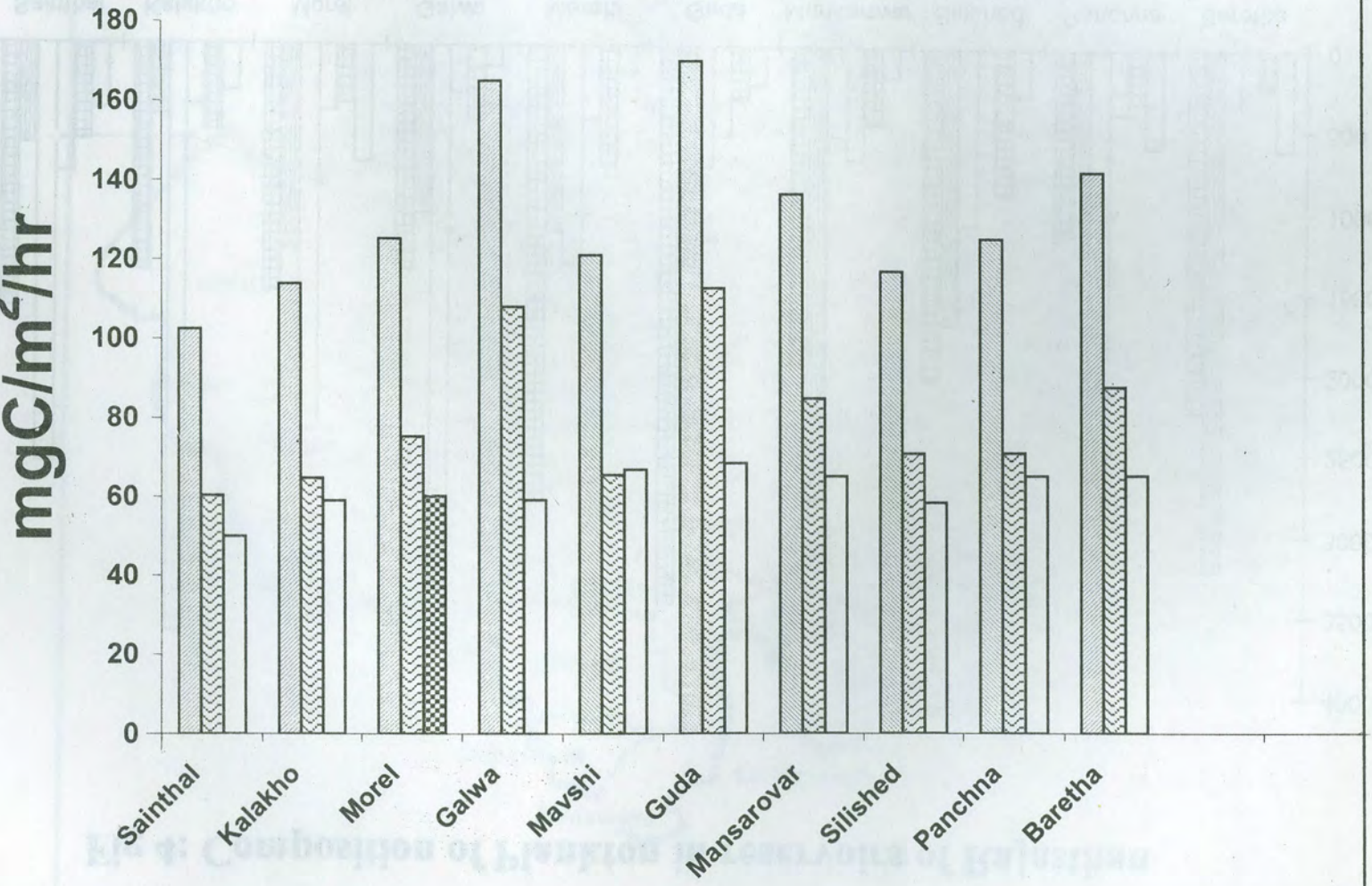
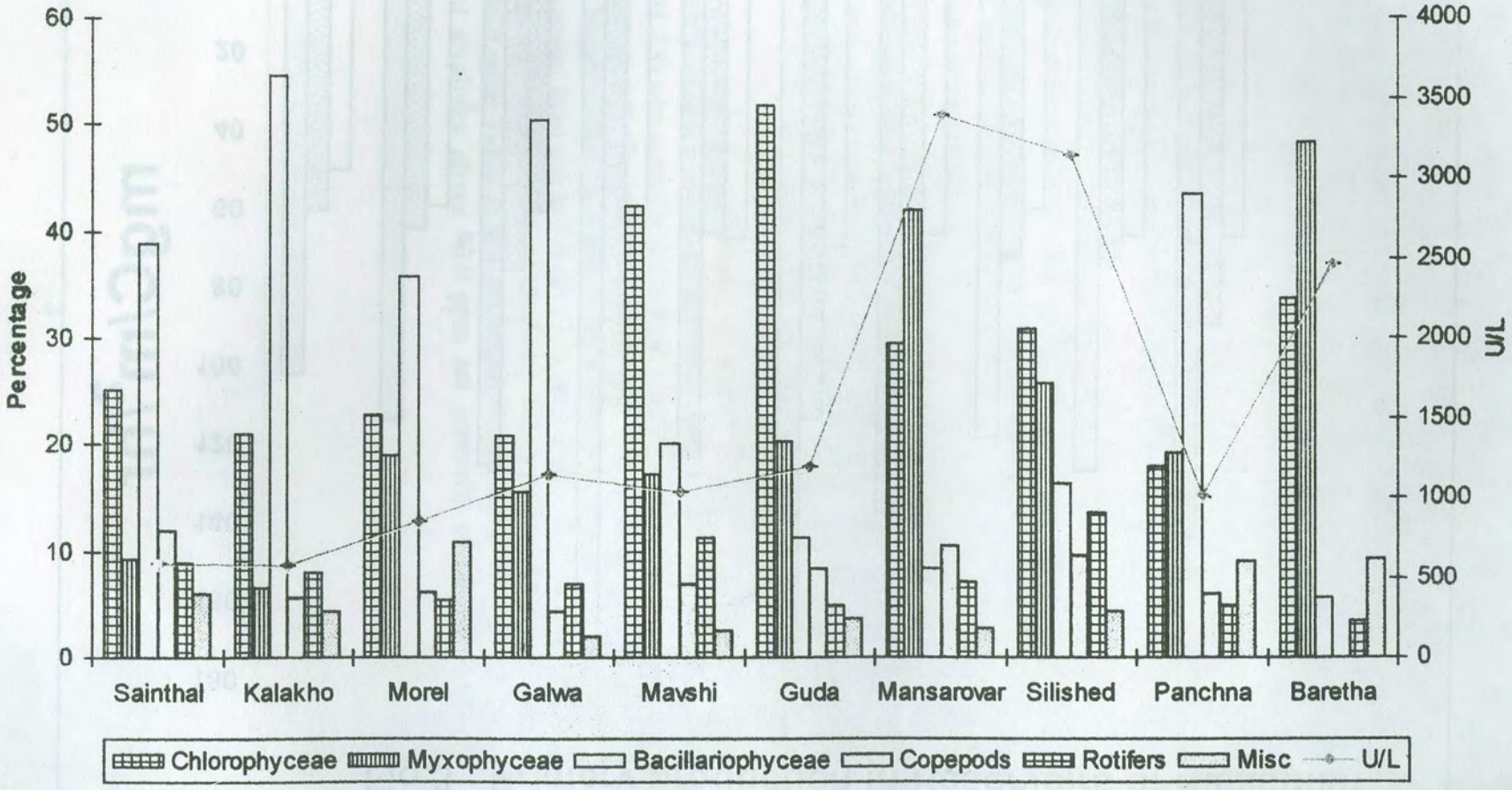


Fig 4: Composition of Plankton in reservoirs of Rajasthan



Calcium concentration was moderate (14.4-22.4 ppm). Magnesium content was of high order, ranging from 7.9 to 17.7 ppm. Total hardness varied between 40.0 to 108.0 ppm. Chloride values fluctuated from 19.8 to 23.8 ppm. Organic matter, an important parameter reflecting the productive nature of water, varied from 2.6 to 5.6 (av. 4.4) ppm indicating high production potential of the reservoir. Phosphate (0.02 ppm) and silicate (1.4 ppm) were of moderate range. High values of specific conductivity (av. 432.3 μmhos/cm) corroborated the productive state of the reservoir. The rich water quality reflects the allochthonus inputs as organic matter and nutrients into the system.

Thermal and chemical stratification :- Depth-wise observations in respect of water temperature (Table 4) did not show presence of thermal stratification in the reservoir as the temperature from surface to bottom (3 m) remain unchanged. Shallowness of the reservoir might have prevented the formation of thermocline in the reservoir. Chemical parameters (Table 4) like dissolved oxygen, total alkalinity and specific conductivity showed signs of weak chemical stratification. Though the Sainthal reservoir is productive oxycline is not strong due to shallowness of the reservoir as well as absence of thermal stratification aiding in constant mixing.

(iii) Primary Productivity :- The average gross production was 102.41 $mgC/m^2/hr$ while the average net production was 60.32 $mgC/m^2/hr$ (Fig. 3). Energy assimilation efficiency (58.9) place the reservoir in the productive category. The potential fish yield in terms of carbon production was estimated as 300 kg/ha/A. This shows the high productive state of the reservoir.

3.5 Biotic communities :-

Plankton :- Studies on aquatic biodiversity revealed an average abundance of 583 u/l of plankton (Fig. 4). It fluctuated from 507 u/l in post-monsoon to 640 u/l in summer Phytoplankton formed 73.3% of the total plankton. Bacillariophyceae constituted 38.8% of the total plankton and were mainly represented by *Cyclotella, Navicula, Melosira, Pinnularia, Frustulia, Gyrosigma, Synedra, Mastogloia, Diatoma, Rhoicosphenia and Meridion*. The major pulse of this group was observed during summer (44.6%). Chlorophyceae formed 25.1% of the total plankton and was mainly represented by *Scenedesmus, Spirogyra, Rhizoclonium, Botryococcus, Euastrum, Colacium* and *Planktosphaeria*. Maximum percentage of this group was recorded in winter. The percentage composition of myxophyceae fluctuated from 5.9 in winter to 11.1% in summer. *Oscillatoria, Anabaena, Merismopedia* and *Nostoc* were the dominant forms in this group.

Table 4 : Depth profile of Sainthal Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	31.0	32	17.0	7.4	8.65	7.3	6.4	7.2	9.6
1	31.0	32	17.0	7.4	8.65	7.4	6.0	7.2	9.6
2	-	32	17.0	-	8.65	7.5	-	7.2	9.0
3	-	32	-	-	8.65	-	-	6.7	-

Depth (m)	Free CO_2			Total alkalinity (ppm)			Sp.conductivity (μmhos)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	Nil	Nil	Nil	184.0	131.6	66	567	394	336
1	Nil	Nil	Nil	184.0	140.0	67	578	386	344
2	-	Nil	Nil	-	146.0	68	-	390	348
3	-	Nil	-	-	150.0	-	-	393	-

Zooplankton were mainly dominated by copepods (*Diaptomus, Cyclops* and nauplii) which formed 11.9% of the total plankton. Rotifers (*Keratella, Brachionus, Polyarthra*) constituted 8.9% of the plankton. The list of plankton encountered during the period of investigation is given in Table 5.

The predominance of clean water species and rare occurrence of pollution indicator species such as *Scenedesmus, Cyclotella, Anabaena* and *Merismopedia* showed the enviornment to be free from pollution.

Periphyton :-Periphytic communities (1458 u/cm^2) were dominated by bacillariophyceae both qualitatively and quantitatively (80.3%; Fig. 5)). Myxophyceae formed 10.9 % followed by chlorophyceae (7.9%). Diatoms were represented by *Cymbella, Cocconeis, Meridion, Tabellaria, Caloneis, Fragilaria, Amphora, Frustulia, Bacillaria, Achnanthes* and *Navicula.* Chlorophyceae was comprised of *Characium* and myxophyceae consisted of *Oscillatoria* and *Schizothrix.*

Macrobenthos :- The standing crop of bottom macrofauna was estimated as 2194 u/m^2 (Table 6). Chironomids dominated the fauna (77.5%) followed by *Chaoborus* (14.2%) and molluscs (8.3%). Maximum concentration of benthos were recorded in post-monsoon season.

Macrovegetation :- Aquatic weeds ranged from 0.2 kg/m^2 in post-monsoon to 1.0 kg/m^2 in summer showing an average 0.53 kg/m^2 wet wt. (Table 7). This showed profuse growth of a variety of marginal macrophytes. The dominant forms were *Hydrilla, Vallisneria* and *Potamogeton.*

3.6 Fisheries :- During the year 1997-98, 12.9 t of fish landed from the reservoir yielding a fish yield of 41.3 kg/ha. Indian major carps constituted 65.3% of the total catch followed by catfishes (24.5%) and other minor carps (10.2%). *C. mrigala* dominated catch with 28.3% of the total yield. *L. rohita* formed 23.1% while *C. catla* constituted 13.9% of the total yield. The catch statistics revealed that inspite of higher stocking rate, the contribution of catla is poor as compared to other species. Thus, the reservoir appears to favour bottom feeders and periphyton nibblers. Other fish species thriving in the reservoir are *W. attu, M. seenghala, M. armatus, C. marulius* and *Notopterus spp.*

3.7 Management :- The available records shows that the reservoir was stocked with 7.28 lakhs of fish seed of catla (36.9%), rohu (31.4%) and mrigal (31.7%) during the period of 1993-94 to 1997-98. Thus, on an average, the stocking rate was 280 per hectare.

Table : 5 : List of plankton encountered in Reservoir of Rajasthan.

Parameters/Plankters	Sainthal	Kalakho	Morel	Galwa	Mavshi	Guda	Mansarovar	Silished	Panchana	Baretha
MYXOPHYCEAE										
Anabaena	+	+	+	+	+	x	+	+	+	+
Oscillatoria	+	x	+	+	+	+	+	+	x	+
Nostoc	+	x	x	+	x	x	+	+	x	x
Merismopedia	+	x	x	x	x	x	x	x	+	+
Phormidium	x	x	+	+	+	+	+	+	+	+
Coccochloris	x	x	x	+	x	+	x	x	x	+
Microcystis	x	x	+	+	+	+	+	+	+	+
Spirulina	x	x	x	x	+	+	x	x	+	+
Aphanocapsa	x	x	x	x	x	x	x	x	x	+
Amphitrix	x	x	x	x	x	x	x	x	x	+
Nodularia	x	+	x	+	+	x	+	+	+	+
DINOPHYCEAE										
Ceratium	x	x	+	x	x	x	x	x	+	+
Peridinium	x	x	+	+	+	+	x	x	+	+
Cystodinium	+	+	+	+	+	x	x	+	x	+

CHLOROPHYCEAE										
Spirogyra	+	x	x	x	+	+	+	x	x	x
Rhizoclonium	+	+	+	+	+	+	+	+	+	+
Scenedesmus	+	x	+	+	+	+	+	+	x	+
Botryococcus	+	x	+	+	+	+	+	+	+	+
Euastrum	+	x	x	x	x	x	x	x	x	x
Planktosphaeria	+	x	x	+	+	+	+	x	x	x
Colacium	+	x	x	x	x	x	x	x	x	x
Schroederia	x	+	x	x	x	x	x	x	x	+
Characium	x	+	x	x	x	+	+	x	+	x
Chlorococcum	x	+	x	x	+	+	+	+	x	x
Staurastrum	x	+	x	+	x	x	x	x	x	x
Arthrodesmus	x	+	x	x	x	x	x	x	x	x
Actinastrum	x	x	+	+	x	x	x	+	x	x
Trochiscia	x	x	+	x	+	+	+	x	+	x
Pediastrum	x	x	x	+	x	+	x	x	x	+
Cosmarium	x	x	x	+	+	+	+	+	x	+
Ulothrix	x	x	x	+	+	+	+	x	x	x
Zygnema	x	x	x	x	x	x	x	x	+	x
Pachycladon	x	x	x	x	+	x	x	x	x	+
Closterium	x	x	x	x	+	x	+	+	x	x
Characiopsis	x	x	x	x	+	+	+	+	x	x

Chlorella	x	x	x	x	x	x	x	+	x	x
BACILLARIOPHYCEAE										
Rhoicosphenia	+	+	x	x	x	x	x	x	x	x
Meridion	+	+	+	x	+	+	+	+	+	+
Cyclotella	+	x	+	+	x	x	x	x	x	x
Navicula	+	+	+	+	+	+	+	+	+	+
Melosira	+	x	+	+	+	+	+	x	+	+
Pinnularia	+	+	+	+	x	x	x	x	x	x
Frustulia	+	+	+	+	+	+	+	+	+	+
Gyrosigma	+	x	x	x	+	+	x	+	x	x
Synedra	+	+	+	+	+	+	+	+	+	+
Mastogloia	+	x	x	x	x	x	x	+	x	x
Diatoma	+	+	+	+	+	+	+	+	+	+
Fragilaria	x	+	x	x	x	+	+	+	x	x
Anchnanthes	x	+	x	+	x	x	x	x	x	x
Amphora	x	+	x	+	+	x	x	x	+	x
Stauroneis	x	+	x	+	+	x	x	x	+	x
Diploneis	x	+	x	x	x	x	x	x	x	x
Diatomella	x	+	x	x	x	x	x	x	x	x
Asterionella	x	x	x	x	x	+	x	x	x	x
Gomphoneis	x	+	x	x	x	x	x	+	x	x

Caloneis	x	x	+	+	x	x	x	x	+	x
Tabellaria	x	x	x	+	+	+	+	+	+	+
Cocconeis	x	x	x	+	+	+	+	+	+	+
Eucocconeis	x	x	x	+	x	+	x	x	x	x
Gomphonema	x	x	x	x	+	x	x	+	+	+
Cymbella	x	x	x	x	+	+	x	+	x	x
Neidium	x	x	x	x	+	x	x	x	x	x
Nitzschia	x	x	x	x	x	+	x	+	x	x
PROTOZOA										
Actinophrys	x	x	+	x	x	x	+	x	+	+
Actinosphaerium	x	x	x	x	x	x	x	x	+	+
Arcella	x	x	x	x	x	x	x	x	+	+
ROTIFERA										
Keratella	+	+	+	+	+	+	+	+	+	+
Polyarthra	+	x	x	x	x	x	x	x	x	x
Brachionus	+	+	+	+	+	+	+	+	+	+
Filinia	+	+	x	x	x	+	+	+	x	x
Notholca	x	+	x	+	x	x	x	x	x	x
Colurella	x	x	+	+	+	+	+	+	x	x
Asplanchna	x	x	x	x	x	x	x	x	+	x
Trichocerca	x	x	x	x	+	x	+	x	x	+

CLADOCERA										
Moina	x	+	x	x	x	x	x	+	x	+
Bosmina	x	x	+	+	+	+	+	+	+	+
Daphnia	+	x	x	x	+	+	+	x	+	x
Diaphanosoma	x	x	+	x	x	+	+	+	+	x
COPEPODA										
Cyclops	+	+	+	+	+	+	+	+	+	+
Diaptomus	+	+	+	+	+	+	+	+	+	+

+ Present

x Absent

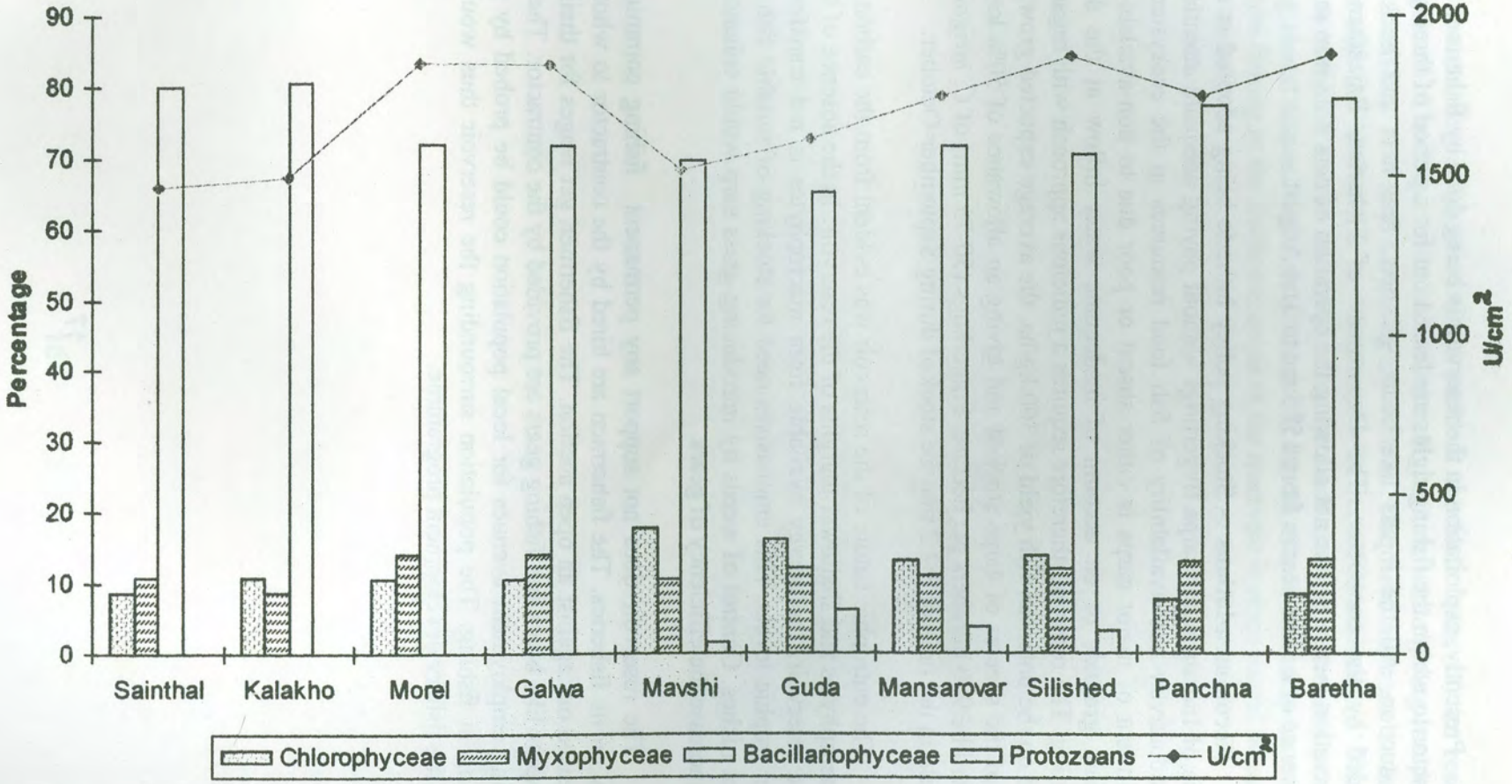
Table : 6 : Composition of Benthos in reservoirs of Rajasthan.

Reservoirs	Chironomids		Chaoborus		Molluscs		Tubificids		Nymphs		Total	
	u/m^2	g/m^2	u/m^2	g/m^2	u/m^2	g/m^2	u/m^2	g/m^2	u/m^2	g/m^2	u/m^2	g/m^2
Sainthal	1700	4.23	311	0.37	183	neg.	-	-	-	-	2194	4.60
Kalakho	178	0.46	-	-	383	1.59	89	0.22	6	neg	656	2.27
Morel	184	0.48	83	0.10	100	neg.	17	0.8	83	0.22	467	1.60
Galwa	200	0.52	100	0.12	100	nil	-	-	17	0.04	417	0.68
Mavshi	384	0.99	133	0.16	133	neg.	100	0.26	-	-	750	1.44
Guda	583	1.50	117	0.14	150	neg.	-	-	16	0.03	866	1.67
Mansarovar	2366	6.06	116	0.14	166	neg.	100	0.26	-	-	2748	6.46
Silished	450	1.34	133	0.16	100	neg.	67	0.17	-	-	750	1.67
Panchana	317	0.69	50	0.06	50	neg.	-	-	33	0.09	450	0.84
Baretha	350	0.87	-	-	217	0.48	-	-	50	0.13	617	1.48

Table :7 : Distribution of Macrovegetation (kg/m2) in Reservoir of Rajasthan

Reservoir	Summer		Post-monsoon		Winter		Average	
	Wet wt.	Dry wt.	Wet wt.	Dry wt.	Wet wt.	Dry wt.	Wet wt.	Dry wt.
Sainthal	1.0	0.15	0.2	0.05	0.4	0.05	0.53	0.97
Kalakho	0.7	0.1	0.11	0.02	0.41	0.08	0.40	0.07
Morel	1.1	0.16	-	-	-	-	0.33	0.53
Galwa	1.2	0.16	0.6	0.15	0.26	0.16	0.69	0.11
Mavshi	2.5	0.15	0.92	0.04	0.85	0.04	1.42	0.07
Guda	0.3	0.05	-	-	0.70	0.03	0.33	0.27
Mansarovar	0.75	0.09	1.0	0.06	0.64	0.04	0.79	0.06
Silished	-	-	-	-	-	-	-	-
Panchna	0.9	0.14	Nil	-	Nil	-	0.30	0.05
Baretha	0.85	0.12	Nil	-	0.5	0.1	0.45	0.07

Fig 5: Composition of Periphyton in reservoirs of Rajasthan



Presently, exploitation 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 against an open auction. All the inputs like boats, gill-nets, drag-nets and hook and lines are provided by the contractor. The Department of Fisheries, Rajasthan, has imposed conservation measures like not allowing the operation of nets < 38 mm mesh bar and the observance of a close season from 15th June to 31st August.

3.8 Recommendations :- Stocking policy hitherto being adopted is confined to the release of Indian major carps fingerlings without paying adequate attention to the levels of productivity and availability of fish food resources in the ecosystem. The natural recruitment of major carps is either absent or poor due to non-availability of suitable breeding grounds or on account of inadequate water inflow at the desired time of spawning. The reservoir therefore requires a judicious approach with regards to stocking. Based on the potential fish yield of 300 kg/ha, the average expected growth of 0.5 kg for each of the species of carps stocked and giving an allowance of 50% loss, the stocking rate will be 900 numbers per hectare. Fingerlings (50-75 mm) of *C. mrigala, L.rohita* and *C. catla* in the ratio of 3:2:2 may be stocked during September-October.

The eutrophic nature of the reservoir was evident from the carbon values, growth of macrophytes and shallower margins of the reservoir. In the absence of herbivore fishes in the reservoir, the energy available from macrophytes is not transferred directly to higher trophic levels. This emphasises need for stocking of suitable fish to utilise these vacant niches. Control of weeds by introducing grass carp would enhance the yield and also increase the efficiency of gears.

The reservoir does not support any permanent fishing community depending solely on its fisheries. The fishermen are hired by the contractor to whom the reservoir are leased out against an open auction. The fishermen get wages for their labour and all the inputs like boats and fishing gears are provided by the contractor. The possibilities of creating employment avenues for local population could be probed by providing them training in fishing. The population surrounding the reservoir thus would be benefited from the fishery development programme.

Further maintaining a high sustained yield is the back bone of the reservoir fisheries management. The Department of Fisheries, Rajasthan, while giving it a priority attention, may carefully develop a monitoring system. The field assistant at landing centre should weigh the landed fish and a species-wise record is maintained. They are also suggested to maintain a strict surveillance on the mesh size and apprehend poachers specially during closed season. Gill-nets of mesh bar 40, 50, 60, 75 mm may be used for fishing. Drag-nets fishing in the shallower areas of the reservoir is more useful because of infestation of weeds.

4. KALAKHO RESERVOIR

4.1 Location :- Kalakho reservoir is situated at latitude 26^0-54'N near village Kalakho across the river Kharndi. It lies in Banganga river basin in the Dausa district of Eastern Rajasthan (Fig. 6). It is nearly 45 year old shallow reservoir constructed for irrigation and flood control purposes in the year 1953.

4.2 Morphometry :- The water spread area of the reservoir at FRL is 724 ha and the catchment area is 133.76 km^2. It falls under the small reservoir category. The shallow character of the reservoir was evident with low mean depth (1.83 m). The other salient features of morphometry are presented in Table 1.

4.3 Meteorological observations :- The atmospheric temperature ranged between 15°C in winter and 33°C in post-monsoon. The average rain fall in the area is 66.0 cm.

4.4 Limnology and productivity :-

(i) Physico-chemical characteristics of soil :- Basin soil of the reservoir was loam in texture with silt (30.2%) and clay (24.6%), Table 2. The soil was deficient with regards to both organic carbon (0.29%) and available phosphorus (4.1 mg/100g). The low phosphorus concentration in the soil reflects rapid assimilation of available phosphorus in the biota. The basin soil, however, seems to have limited impact on the water quality as the later mainly derives the nutrients from the catchment area.

(ii) Physico-chemical characteristics of water :- Barring summer and rainy months, the water of Kalakho reservoir remains clear, imparting a greenish tinge. Transparency fluctuated from 23 in post-monsoon to 81 cm in winter (Table 3). Surface water temperature varied between 17 and 32^0C. The water is alkaline (pH 7.8) which enable the normal ion-exchange of fresh water fishes. Dissolved oxygen varied from 6.8 to 11.4 (av. 8.8) ppm. Free CO_2 was absent during all the seasons(Table 8). The seasonal variation in total alkalinity was quite discernible with maximum values in summer (196.0 ppm) which declined during post-monsoon. Assessment of the productivity based on total alkalinity (123 ppm) reflected the water bodyto be fairly productive.

Calcium concentration was moderate (12.8-20.8 ppm). Magnesium content was of high order, ranging from 11.8 to 24.2 ppm. Total hardness ranged between 52.0 and 100.0 ppm. Chloride values fluctuated from 19.9 to 34.0 ppm. Water was deficient with regards to phosphate (0.01 ppm) and silicate (1.2 ppm). Moderate values of specific conductivity ranging from 142.0 to 330.0 µmhos/cm reflected the productive state of the reservoir. The rich water quality reflects the transport of allochthonus dissolved nutrients and their leaching into the system.

Thermal and chemical stratification :- Depth-wise observations in respect of water temperature (Table 8) did not show presence of thermal stratification in the reservoir. The water temperature from surface to bottom (3 m) remained uniform. Absence of thermal stratification in Kalakho reservoir could be due to free mixing because of the shallowness of the reservoir. Chemical parameters (Table 8) like dissolved oxygen and specific conductivity showed signs of weak chemical stratification.

iii) Primary Productivity :- Observations on primary productivity showed an average gross production of 113.7 $mgC/m^2/hr$. The average net production was 64.63 $mgC/m^2/hr$ (Fig. 3). Thus, the expected potential fish yield in terms of carbon production is 330 kg/ha/A. This shows the high productive state of the reservoir. Energy assimilation efficiency (56.8) shows the productiveness of water body.

4.5 Biotic communities :-

Plankton :- The plankton population ranged from 405 u/l in post-monsoon to 746 u/l in summer and had an annual average production of 564 u/l. Bacillariophyceae formed 54.6% of the total plankton population (Fig. 4). The major pulse was observed during winter (78.4%). The common forms observed were *Rhoicosphenia, Meridion, Diatoma, Navicula, Fragilaria, Tabellaria, Achnanthes, Amphora, Pinnularia, Stauroneis, Synedra, Diploneis, Diatomella* and *Gomphonema*. Chlorophyceae constituted 20.9% of the total plankton and was mainly represented *by Schroederia, Characium, Rhizoclonium, Chlorococcum, Staurastrum* and *Arthrodesmus*. Maximum percentage of this group was recorded in summer . The percentage composition of myxophyceae fluctuated from 4.3 in winter to 10.3 in post-monsoon. *Anabaena* was the dominant flora observed. Zooplankton were mainly dominated by rotifers (*Keratella, Brachionus, Notholca, Filinia*) and formed 8.0% of the total plankton. Copepods (*Diaptomus, Cyclops* and nauplii*)* constituted 5.6% of the plankton.

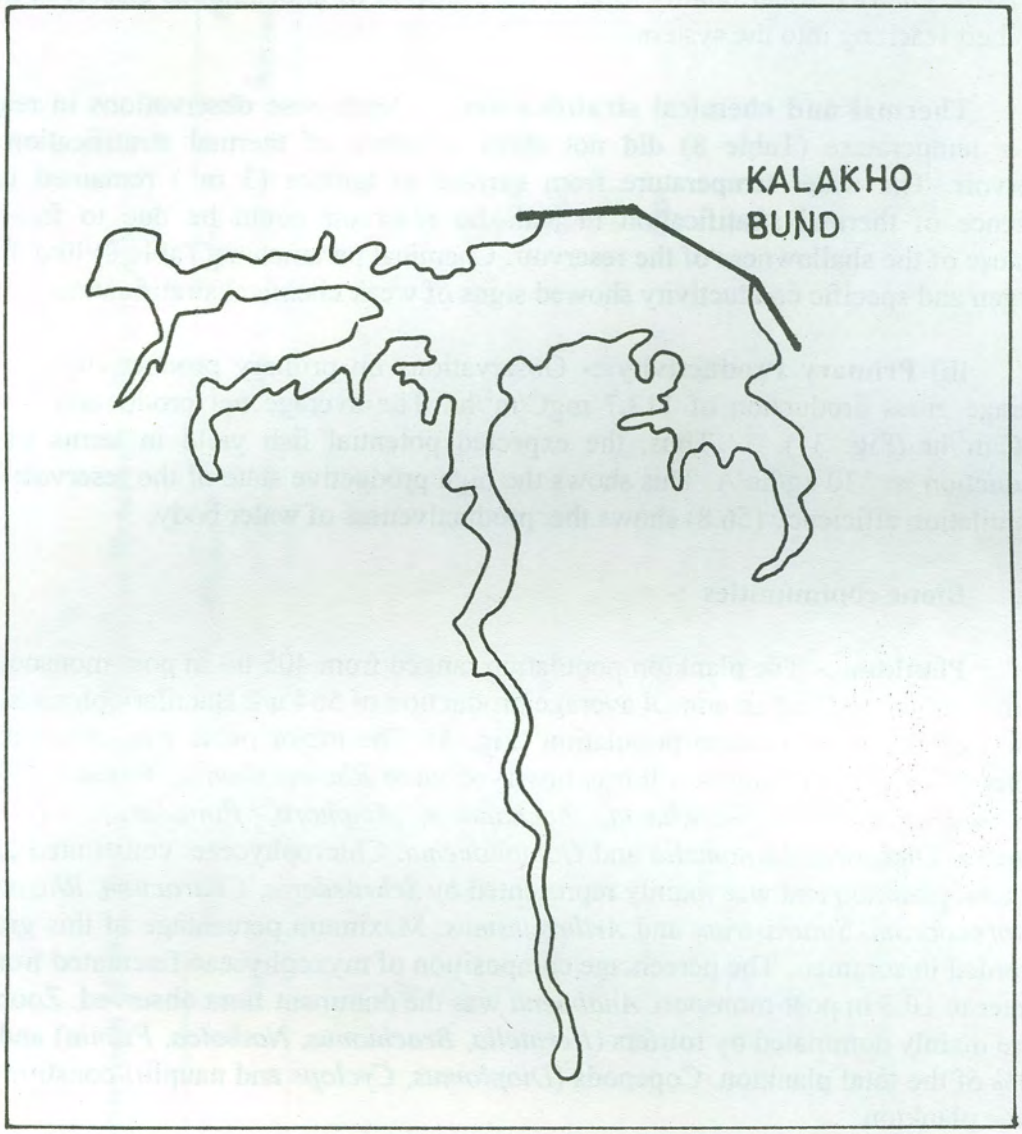


FIG. 6 - SCHEMATIC VIEW OF KALAKHO RESERVOIR

VIEW OF KALAKHO RESERVOIR

Table 8 : Depth profile of Kalakho Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	29.0	32	17.0	7.3	8.2	7.9	6.8	8.3	11.4
1	29.0	32	17.0	7.3	8.2	7.9	6.4	7.7	11.2
2	-	32	17.0	-	8.2	8.0	-	7.7	11.2
3	-	32	-	-	8.2	-	-	7.0	-

Depth (m)	Free CO_2			Total alkalinity (ppm)			Sp.conductivity (μmhos)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	Nil	Nil	Nil	196.0	124	50	330	220	142
1	Nil	Nil	Nil	196.0	124	52	332	220	137
2	-	-	Nil	-	124	60	-	223	136
3	-	Nil	-	-	124	-	-	223	-

Pollution indicator species such as *Fragilaria* and *Anabaena* were rarely encountered. This showed the predominance of clean water indicator species in the ecosystem.

Periphyton :- Periphyton population ranged between 1164 u/cm^2 in post-monsoon to 1746 u/cm^2 in winter and had an average abundance of 1487 u/cm^2 (Fig 5). Bacillariophyceae (80.4%) dominated over chlorophyceae (10.9%) and myxophyceae (8.8%). Bacillariophyceae was rich both qualitatively and quantitatively and was represented by *Meridion, Cymbella, Achnanthes, Tabellaria, Caloneis, Navicula, Fragilaria, Mastogloia, Synedra, Cocconeis, Epithemia, Amphora, Diatoma, Pinnularia, Eunotia. Characium* represented chlorophyceae while *Schizothrix* represented myxophyceae.

Macrobenthos :- Macrobenthos of Kalakho reservoir were dominated by molluscs (58.2%; Table 6). The average abundance of macrobenthos was of moderate level (656 u/m^2). It ranged from 250 u/m^2 in summer to 1317 u/m^2 in post-monsoon . The poor abundance of macrobenthos among biotic communities may be due to limited concentration of organic matter in the soil.

Macrovegetation :- Observations on macrophytes from Kalakho reservoir showed infestation at the average value of 0.406 kg/m^2 wet wt. (Table 7). The infestation of macrophytes being more in winter due to receded water level than post-monsoon. The dominant forms were *Potamogeton, Hydrilla* and *Vallisneria.*

4.6 Fisheries :- During the year 1997-98, a total of 31.4 t of fish landed from the reservoir yielding in a fish yield of 72.3 kg/ha. Indian major carps formed 60.7% of the total catch. It was followed by catfishes (27.0%) and other fishes (12.3%). *C. mrigala, L. rohita* and *C. catla* formed 21.8, 20.4 and 18.0% of the total catch respectively. Other fishes thriving in the reservoir are *W. attu, M. seenghala, Notopterus, M. armatus* and *Channa spp.* The catch statistics indicate presence of good population of predators. The size of stocking therefore would be an important factor for better survival of major carps in the system.

4.7 Management :- According to available records the stocking of Indian major carps has been erratic. A total of 51.46 lakhs of fish seed of catla (7.2%), rohu (48.6%) and mrigal (44.2%) were stocked at an average stocking rate of 1422/ha during the period from 1993-94 to 1997-98. Thus, the reservoir appears to have been over stocked. No standard on the size of the stocked fish seed have been followed.

The fishing rights of the reservoir are leased out for a period of three years to a contractor in an open auction. Fishing in the reservoir is irregular and is being carried out by fishing parties brought from other towns. Fishing gear employed in the reservoir are mainly of three types viz. gill-nets, hook and lines and drag-nets. Aquatic weeds invariably poses obstructions to successful fishing operation.

4.8 Recommendations :-

Kalakho being a small reservoir has fisheries depending on the fishes planted from out side and its fisheries management thus lean heavily on a sustained annual stocking. Thus, there is a need for improvement in the management strategy basing on the biogenic productivity, the trophic structure and the function of the reservoir. Fish culture in Kalakho reservoir, hitherto being practised by the contractor, consists of planting seeds of Indian major carps on an arbitrary basis without taking into consideration the biogenic capacity of the ecosystem. Based on the productive potential of the reservoir (330 kg/ha), a stocking rate of 1000 fingerlings per hectare may be adopted for the reservoir. It is recommended that fingerlings of *C. mrigla, L. rohita* and *C. catla* in ratio of 3:2:2 may be stocked during September-October. Stocking of fingerlings in the size range of 50-75 mm may be adopted for better survival in view of the presence of good population of predators.

Kalakho reservoir also does not support any permanent fishing community as observed in the case of Sainthal reservoir. The contractor to whom the reservoir is leased out hire fishermen for fishing. Hence, for the benefit of local population, surrounding the reservoir, from the fishery development programme, the exploitation of reservoir under the aegis of a co-operative society may be probed. Gill-nets of mesh bar 40, 50, 60, 75 mm may be used for fishing. For controlling the predator, *W. attu* and *M. seenghala* selective fishing through hook and line may be taken up. However, a small population of predators would help cropping down of the weed fishes which other-wise compete for food with the stocked fish seed of Indian major carp.

The various aspects of management of fisheries in reservoir viz. limits of fishermen number, fishing gear, catch characteristics and closed season may be monitored for optimum utilization of the reservoir and for economic returns.

5. MOREL RESERVOIR

5.1 Location :- Morel reservoir is situated at latitude 26°-26'N near Lalsot town. It lies on Banas river basin in the Dausa district of Eastern Rajasthan (Fig. 7). It is an old reservoir constructed for irrigation purposes in the year 1952. It is fed by the rivers Kanota and Chakshi. The reservoir was reconstructed in the year 1984.

5.2 Morphometry :- The reservoir has a water spread of 1564 ha at FRL and a catchment area of 3346 km^2. It has a mean depth of 4.96 m.. The other salient features of morphometry are presented in Table 1.

5.3 Limnology and productivity :-

(i) Physico-chemical characteristics of soil :- The basin soil was sandy loam in texture [sand (71.6%) and silt (17.1%) Table 2]. The soil was deficient with regards to both organic carbon (0.33%) and available phosphorus (3.1 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 later mainly derives the nutrients from the catchment area.

(ii) Physico-chemical characteristics of water :- Barring summer months, the water of Morel reservoir remains clear imparting a greenish tinge. Transparency fluctuated from 26 cm in summer to 86 cm in post-monsoon. Surface water temperature varied between 21.0 and 34.0°C (Table 3). The water is alkaline (7.3) which enable the normal ion-exchanges of fresh water fishes. Dissolved oxygen ranged between 6.8 and 10.4 ppm. Free CO_2 was absent in summer and winter while it appeared in post-monsoon (4.0 ppm) months (Table 9). The seasonal variation in total alkalinity was quite discernible with minimum values in post-monsoon (124.0 ppm) and maximum in summer (250.0 ppm). The total alkalinity (181.0 ppm) thus was conducive to high fish productivity.

VIEW OF MOREL RESERVOIR

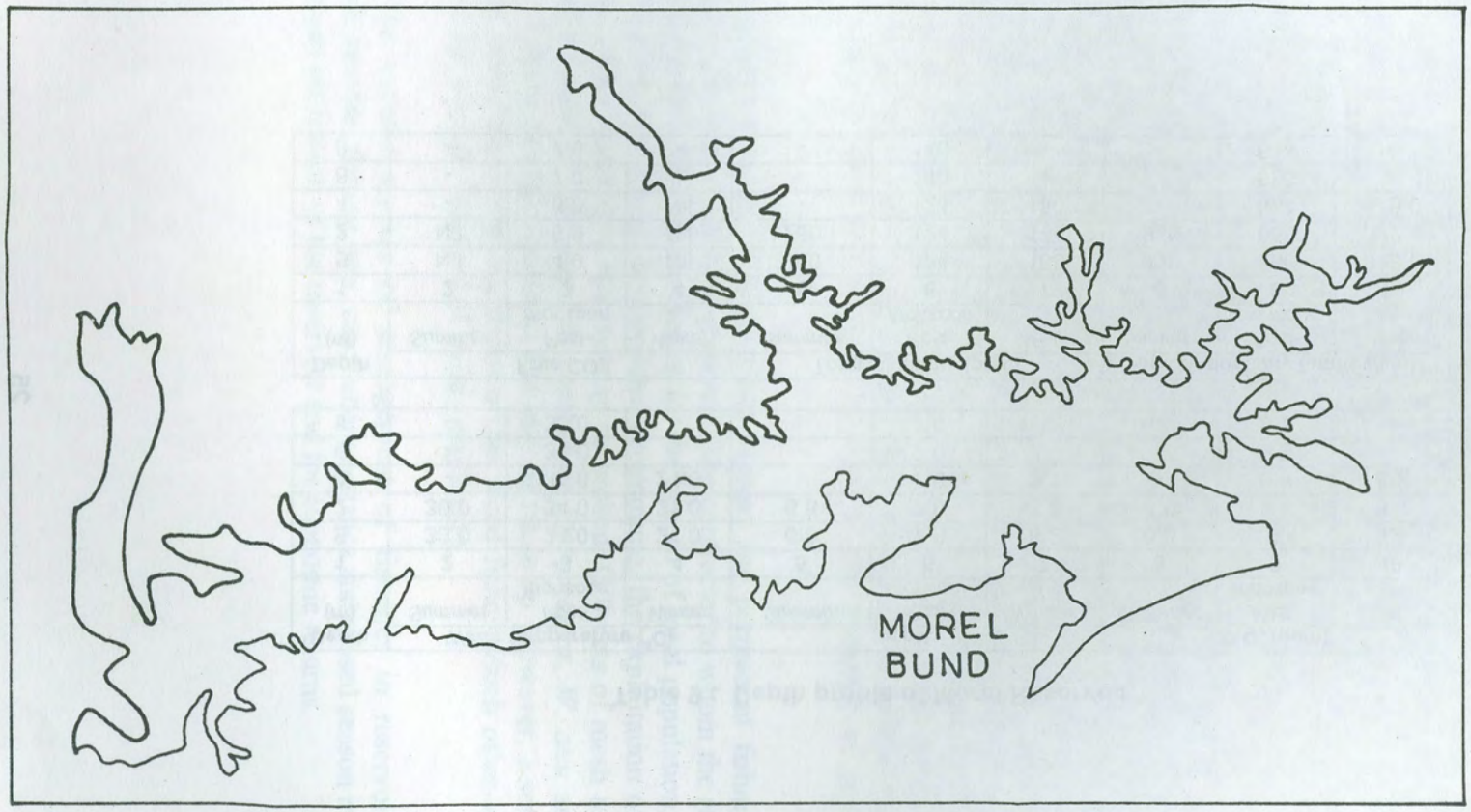


FIG. 7- SCHEMATIC VIEW OF MOREL RESERVOIR

Table 9 : Depth profile of Morel Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	30.0	34.0	21.0	6.8	7.0	8.2	6.8	10.4	9.4
2	30.0	34.0	21.0	6.8	7.0	8.2	6.0	9.6	8.8
4	-	34.0	21.0	-	7.0	8.1	-	9.6	8.2
6	-	34.0		-	7.0		-	9.2	-
8	-	33.0		-	7.0		-	9.2	-

Depth (m)	Free CO_2			Total alkalinity (ppm)			Sp.conductivity (μmhos/cm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	Nil	4.0	Nil	250	124	168	959	660	328.0
2	Nil	6.0	Nil	260	124	174	956	655	322.0
4	-	6.0	Nil	-	124	180	-	654	310.0
6	-	7.0	-	-	140	-	-	650	-
8	-	7.0	-	-	140	-	-	644	-

Calcium concentration was moderate varying between 19.5 and 32.0 ppm. Magnesium content ranged from 1.2 to 10.8 ppm. Chloride values fluctuated from 9.7 to 69.6 ppm . Water was deficient with regards to phosphate (0.04 ppm) and silicate (1.8 ppm). The values of dissolved organic matter ranged from 1.4 to 5.2 ppm indicating fairly high content of dissolved organic matter *vis-a-vis* productive state of the reservoir. Specific conductivity fluctuated from 328.0 to 959.0 µmhos/cm. High values of specific conductivity supported eutrophic character of the reservoir. These hydrological parameters clearly suggest the medium productive potential of the reservoir.

Thermal and chemical stratification :- Depth-wise observations in respect to water temperature (Table 9) did not show presence of thermal stratification. The reservoir water in post-monsoon had a maximum difference of 1.0°C from surface (34.0°C) to 8 m (33.0°C). Post-monsoon mixing of different layers could have prevented the formation of thermocline . In summer the shallowness of the reservoir aids in free mixing which prevents the thermal stratification. During post-monsoon chemical parameters (Table 9), particularly free CO_2, total alkalinity, dissolved oxygen and specific conductivity, did show signs of chemical stratification indicating productive nature of the ecosystem.

(iii) Primary productivity :- The primary productivity studies exhibited an average annual gross carbon production of 125.0 $mgC/m^2/hr$. The average net production was 75.0 $mgC/m^2/hr$ (Fig. 3). Thus, the expected fish yield in terms of carbon production is 365 kg/ha. This shows the high productive state of the reservoir. Energy assimilation efficiency (60.0) shows the productive character of water body.

5.4 Biotic communities :-

Plankton :- The population fluctuated from 710 u/l in summer to 1044 u/l in winter and had an annual average production of 844 u/l (Fig. 4). Phytoplankton constituted 83.4% of the total plankton. Among phytoplankters, bacillariophyceae was dominant. It formed 35.8% of the plankton population and was mainly represented by *Cyclotella, Meridion, Diatoma, Caloneis, Melosira, Pinnularia, Tabellaria, Frustulia, Synedra* and *Navicula.* Chlorophyceae constituted 22.8% of the total plankton and was represented by *Actinastrum, Trochiscia, Botryococcus, Rhizoclonium* and *Scenedesmus.* Dinophyceae (5.9%) was represented by *Peridinium, Ceratium* and *Cystodinium.* The percentage composition of myxophyceae varied from 11.5 in winter to 30.2 in post-monsoon. *Microcystis* followed by *Anabaena, Phormidium* and *Oscillatoria* were the dominant flora observed. Zooplankton were mainly dominated by copepods (*Cyclops, Diaptomus* and nauplii) and formed 6.1% of the total plankton. Rotifers (*Brachionus,*

Colurella and *Keratella*) constituted 5.5% of the plankton. The predominance of clean water indicator species among the phytoplankton community, showed the region is free flow pollution.

Periphyton :- Periphytic communities were dominated by bacillariophyceae both qualitatively and quantitatively (72.0%). Periphyton population ranged from 1649 to 2134 (av. 1843) u/cm^2. Myxophyceae formed 14.0% (Fig. 5) followed by chlorophyceae (10.6%). Diatoms were represented by *Cymbella, Mastogloia, Pinnularia, Caloneis, Diatoma, Tabellaria, Synedra, Melosira, Frustulia, Gomphonema, Gryosigma, Meridion* and *Navicula*. Chlorophyceae was comprised of *Characium, Cladophora* and myxophyceae flora constituted of *Oscillatoria* and *Schizothrix.*

Macrobenthos :- The standing crop of bottom macrofauna was estimated as 469 u/m^2 (Table 6). Chironomids formed 39.2% of the total population followed by molluscs (21.4%),*Chaoborus* (17.7%) and nymphs (17.7%).

Macrovegetation :- Aquatic weeds occurred during summer season (1.1 kg/m^2) only (Table 7). The weeds observed were *Potamogeton, Vallisneria* and *Hydrilla.*

5.5 Fisheries :- A variety of fishes exists in the ecosystem which mainly includes *C. catla, L. rohita, C. mrigala, W. attu, M. seenghala, L. calbasu, L. gonius, L. bata, P. sarana, P. ticto, P. stigma, O. cotio, O. bimaculatus, M. cavasius, C. marulius, C. Punctatus, A. nama. A. ranga. C. reba, N. chitala, N. notopterus* and *M. armatus*. During 1998-99, a total of 112.0 t of fish landed from the reservoir ,yielding in a fish yield of 119.4 kg/ha. *C. catla* formed 28.0% of the landings followed by *L. rohita* (27.4%), *C. mrigala* (21.2%), catfishes (11.7%) and other minor carps (11.7%).

5.6 Management :- Available records of stocking showed that a total of 63.91 lakhs of fish seed of catla (48.5%), rohu (29.6%) and mrigal (21.9%) were stocked at an average stocking rate of 817 numbers per hectare during the period from 1993-94 to 1997-98.

The fishing rights of the reservoir are leased out for a period of three years to a contractor in an open auction. Fishing in the reservoir is being carried out by parties consisting of 52 fishermen having 26 boats. Fishing gears employed are gill-nets, hook and lines and drag-nets.

5.7 Recommendations:-

The limnological investigations of Morel reservoir exhibited high productive status of the water body with an annual yield of 119.4 kg/ha against the productive potential of 365 kg/ha. The exploitation efficiency which gives the extent of utilization of net energy fixed by producers as fish is 0.33%. Though the efficiency is higher than in many other large reservoir, it is comparatively lower than the other small reservoir *viz* Gulariya (0.61%) and Bachhra (0.58%).

The stocking policy hitherto being adopted by the contractor mainly consists of release of carp seed at the rate of 500/ha as fixed by the Deptt. of Fisheries, Rajasthan, without taking into consideration the levels or ratio of the species to be stocked based on the biogenic capacity of the ecosystem. Stocking policy therefore is highly dependent on the availability of fish seed rather than on actual need. It is recommended that 1100 fingerlings per hectare in the size range of 50-75 mm and ratio of mrigala 3, rohu 2, catla 2 may be stocked annually. The stocking rate for the reservoir has been determined on the basis of its potential fish yield and average growth of the fishes as described by Huet (1960).

Operation of gill nets of mesh bar varying from 40 to 150 mm, with more number of nets in 40 to 80 mm mesh bar are recommended. The fishing effort should also be enhanced with more fishermen and by providing them with nets, fishing boats as per their requirement.

6. GALWA RESERVOIR :

6.1 Location :- Galwa reservoir is located at latitude 25^0-31'N near village Uniyara across the river Galwa in Benas river basin in the Tonk district , Rajasthan (Fig. 8). The earth-fill dam was constructed in 1960 for irrigation purposes.

6.2 Morphometry :- The reservoir has a water spread area of 1800 ha at FRL and a catchment area of 380 km^2. It falls under the medium reservoir category. At gauge level, the reservoir has a maximum depth of 5.79 m while the mean depth is 2.7 m The other salient features of morphometry are presented in Table 1.

6.3 Meteorological observations :- The atmospheric temperature fluctuated from 22°C in winter to 38°C in post-monsoon. The average rain fall in the area is reported to be 63.5 cm.

6.4 Limnology and productivity :-

i) Physico-chemical characteristics of soil :- The basin soil of the reservoir is sandy loam in texture (Table 2) and low in organic carbon (0.33%) as well as in available phosphorus (2.3 mg/100g). The available nitrogen (38.4 mg/100g) was however of medium range.

ii)Physico-chemical characteristics of water :- Transparency varies between 18 (summer) and 72 cm (winter). The surface water temperature range from 20 to 35^0C (Table 3). The water is alkaline (7.5) which enables the normal ion-exchanges of fresh water fishes. Dissolved oxygen fluctuated from 7.2 to 9.6 ppm. Free CO_2 was absent in post-monsoon and winter months while it appeared in summer (11.2 ppm). The seasonal variation in total alkalinity was quite discernible with minimum values in post-monsoon (170.0 ppm) and maximum in summer (256.0 ppm). Assessment of the productivity based on the total alkalinity (199.0 ppm) reflected the productive state of the water body.

Calcium content of water was high (av. 32.4 ppm). Magnesium concentration ranged from 1.4 to 10.8 (av. 6.3) ppm. Chloride values varied from 12.8 to 47.0 ppm. Water had moderate values of phosphate (0.07 ppm) and silicate (2.0 ppm). Dissolved organic matter ranged from 1.6 to 6.4 ppm indicating fairly high content of dissolved organic matter *vis-a-vis* productive state of the reservoir. Specific conductivity fluctuated from 180.0 to 336.0 µmhos/cm and supported the productive character of the reservoir.

Thermal and chemical stratification :- Depth-profile observations upto 4 m in respect of water temperature (Table 10) did not show presence of thermal stratification. The reservoir water in post-monsoon had a maximum difference of 1^0C from surface to 4 m depth. In summer the shallowness of the reservoir aids in free mixing which prevents the formation of thermocline. Similarly, in post-monsoon the absence of thermal stratification could be due to mixing of different layers. During post-monsoon and winter, chemical parameters (Table 10) like dissolved oxygen, total alkalinity and specific conductivity did show signs of weak chemical stratification reflecting productive character of the water body.

iii) Primary productivity :- Studies on primary productivity exhibited an annual average gross production of 164.67 and net production of 107.81 mgC/m^2/hr (Fig.3). Energy assimilation efficiency (65.5) was nearer to that of productive reservoir. The potential fish yield in terms of carbon production is 480 kg/ha/A which showed the high productive state of the reservoir.

6.5 Biotic communities :-

Plankton :- Studies on aquatic biodiversity revealed an average abundance of 1135 u/l of plankton population (Fig. 4). Bacillariophyceae, on an average, formed 50.5% of the total plankton and were mainly represented by *Synedra, Navicula,, Tabellaria, Diatoma, Frustulia, Cocconeis, Amphora, Eucocconeis, Stauroneis, Pinnularia, Achnanthes, Melosira, Caloneis* and *Cyclotella*. Chlorophyceae represented by *Actinastrum, Botryococcus, Rhizoclonium, Scenedesmus, Pediastrum, Planktosphaeria, Cosmarium, Ulothrix* and *Staurastrum* formed 20.8% of the plankton. Myxophyceae constituted 15.6% of plankton and were represented by *Microcystis, Nostoc, Phormidium, Oscillatoria, Anabaena* and *Coccochloris*. Among zooplankton, rotifers (*Keratella, Brachionus, Colurella, Notholca*) formed 6.8% of plankton followed by copepods (*Diaptomus, Cyclops* and nauplii; 4.3%).

Periphyton :- Periphyton population ranged from 686 u/cm^2 in summer to 1860 u/cm^2 in winter . Periphytic communities of the reservoir were dominated by bacillariophyceae both quantitatively and qualitatively (Fig.5). It formed 71.9% of periphyton and were represented by *Pinnularia, Diploneis, Synedra, Stauroneis, Diatoma, Tabellaria, Caloneis, Fragilaria, Amphora, Gyrosigma, Melosira* and *Cymbella. Characium, Cladophora* represented chlorophyceae while *Oscillatoria* and *Schizothrix* represented myxophyceae.

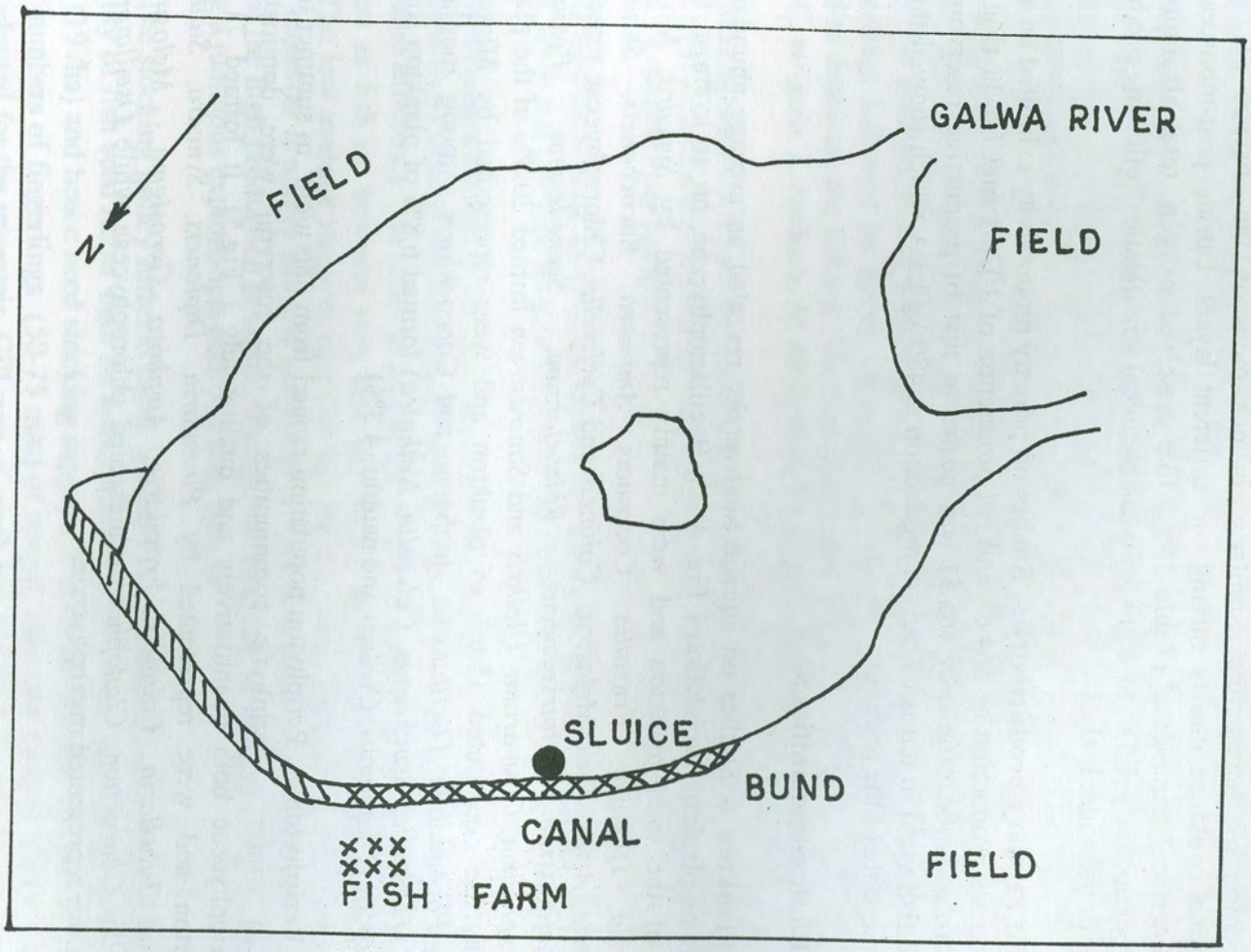


FIG. 8- SCHEMATIC VIEW OF GALWA RESERVOIR

VIEW OF GALWA RESERVOIR

Table 10 : Depth profile of Galwa Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	30.0	35.0	20.0	7.6	6.8	8.3	7.2	8.8	9.6
2	30.0	34.5	20.0	7.6	6.8	8.3	6.8	8.6	9.2
4	-	34.0	20.0	-	6.8	8.2	-	8.4	8.8

Depth (m)	Free CO_2			Total alkalinity (ppm)			Sp.conductivity (μmhos/cm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	11.2	Nil	Nil	256	170	172	336	180	160
2	11.6	Nil	Nil	256	166	180	335	167	156
4	-	Nil	Nil	-	164	184	-	158	152

Macrobenthos :- Macrobenthos of Galwa reservoir were dominated by chironomids (48.0%; Table 6). The average standing crop of benthos was of moderate level (417 u/m^2). It ranged from 300 u/m^2 in post-monsoon to 550 u/m^2 in winter . The poor abundance of macrobenthos among the biotic communities may be due to limited concentration of organic matter in the soil.

Macrovegetation :- Abundance of macrophytes fluctuated from 1.20 kg/m^2 wet wt. in summer to 0.260 kg/m^2 wet wt. in winter (Table 7). The average standing crop of macrophytes was 0.7 kg/m^2 wet wt. *Hydrilla, Vallisneria* and *Potamogeton* were the dominant forms observed.

6.6 **Fisheries** :- The reservoir was not leased out for fishing in the year 1998-99. However, fish records for the year 1997-98 showed a total of 11.38 t of fish landed from the reservoir yielding in a fish yield of 10.5 kg/ha. Major carps constituted 42.1% of the total landings followed by minor carps (32.7%) and cat fishes (25.2%). *C. catla* was reported to dominate the fishery . The fish species thriving in the reservoir are *C. catla, L. rohita, C. mrigala, L. calbasu, M. seenghala, W. attu, C. marulius, E. vacha* and *R. rita.*

6.7 **Management** :- There was no stocking in the year 1995-96 and 1997-98 where as 1.0 lakh of fish seed were stocked in the year 1996-97. Thus, on an average, the stocking rate was 19 numbers per hectare.

Drag-nets fishing dominates because of heavy infestation of weeds. Bottom set gill-nets, hook and line and fasla nets are also used for fishing.

6.8 **Recommendations** :-The limnological investigations of Galwa reservoir revealed high productive status of the water body with the productive potential of 480 kg/ha. The exploitation efficiency , an index to assess the extent of utilization of net energy fixed by producers as fish is however very low viz. 0.02% in view of low annual yield (10.5 kg/ha).The low average stocking rate (19 ha) for the years 1995-96 to 1997-98 suggest that the reservoir is poorly stocked and could be one of the reasons for the low fish yield inspite of the high production potential. Fish production can be enhanced significantly by adopting a judicious exploitation-cum-stocking policy.

The stocking policy hitherto being adopted by the contractor is dependent on the availability of fish seed rather than on actual need. The reservoir, has so far been poorly stocked (19 /ha) and hence need stocking support. It is recommended that a stocking rate of 1400 numbers of fingerlings (50-75 mm) of mrigal, rohu and catla (3:2:2) per hectare may be adopted for the reservoir. Gill-nets of mesh bar 40,50,60,75 mm may be used for

fishing. Since the reservoir is shallow the depth of nets need to be adjusted according to the water level prevailing in the reservoir. Drag-nets fishing in the reservoir is more useful because of heavy infestation of weeds. Exploitation of the reservoir under the aegis of a co-operative society may prove beneficial to the local population from the fishery development programme. The various aspects of management of fisheries in reservoir be monitored carefully.

7. MAVSHI RESERVOIR :

7.1 Location :- Mavshi reservoir is located at latitude 26^0-25'N in the district of Tonk, Rajasthan. It lies in the Banas river system (Fig. 9)

7.2 Morphometry :- The reservoir came into existence in the year 1960 due to construction of a dam across the confluence of the river Mavshi and Bandi. It has a water spread area of 1600 ha at FRL and a total catchment area of 5575 km^2. It falls under the medium reservoir category. The C/A ratio of 48 reveals more inputs of allochthonous nutrients through the catchment. The mean depth (3.0 m) indicates shallow character of the reservoir.

7.3 Meteorological observations :- The atmospheric temperature varied from 24 in winter to 35°C in summer.

7.4 Limnology and productivity :-

i) Physico-chemical characteristics of soil :- The basin soil of the reservoir was silt loam in texture (Table 2). Soil was alkaline (pH 8.0) and was deficient with regards to organic carbon (0.34%) and available phosphorus (3.0 mg/100g). Available nitrogen (39.3 mg/100g) was in moderate range. The low phosphorus concentration in the soil reflects rapid assimilation of available phosphorus in the biota.

ii) Physico-chemical characteristics of water :- The water temperature varied from 18°C in winter to 31°C in summer. The alkaline water (pH 8.4) is favourable for fish growth. Barring summer, the water remains clear imparting a greenish tinge. Transparency fluctuated from 26 cm in summer to 42 cm in post-monsoon. Low transparency in summer may be attributed to shallowness of the reservoir coupled with high wind action. Dissolved oxygen varied from 5.6 to 9.2 (av. 7.9) ppm. Free CO_2 was absent during all the seasons. The seasonal variation in total alkalinity was quite discernible with minimum value in post-monsoon (70.0 ppm) and maximum value in winter (154.0 ppm). Assessment of the productivity based on total alkalinity (106.0 ppm) reflected the water body fairly productive.

Calcium content of water ranged between 18.0 and 21.0 ppm. Magnesium concentration was of high range (18.6-22.8 ppm). Chloride values fluctuated from 39.8 to 119.3 ppm. High values of dissolved organic matter (2.5-8.4 ppm) reflected high productive potential of the reservoir. Phosphate (0.02 ppm) and silicate (2.2 ppm) were of

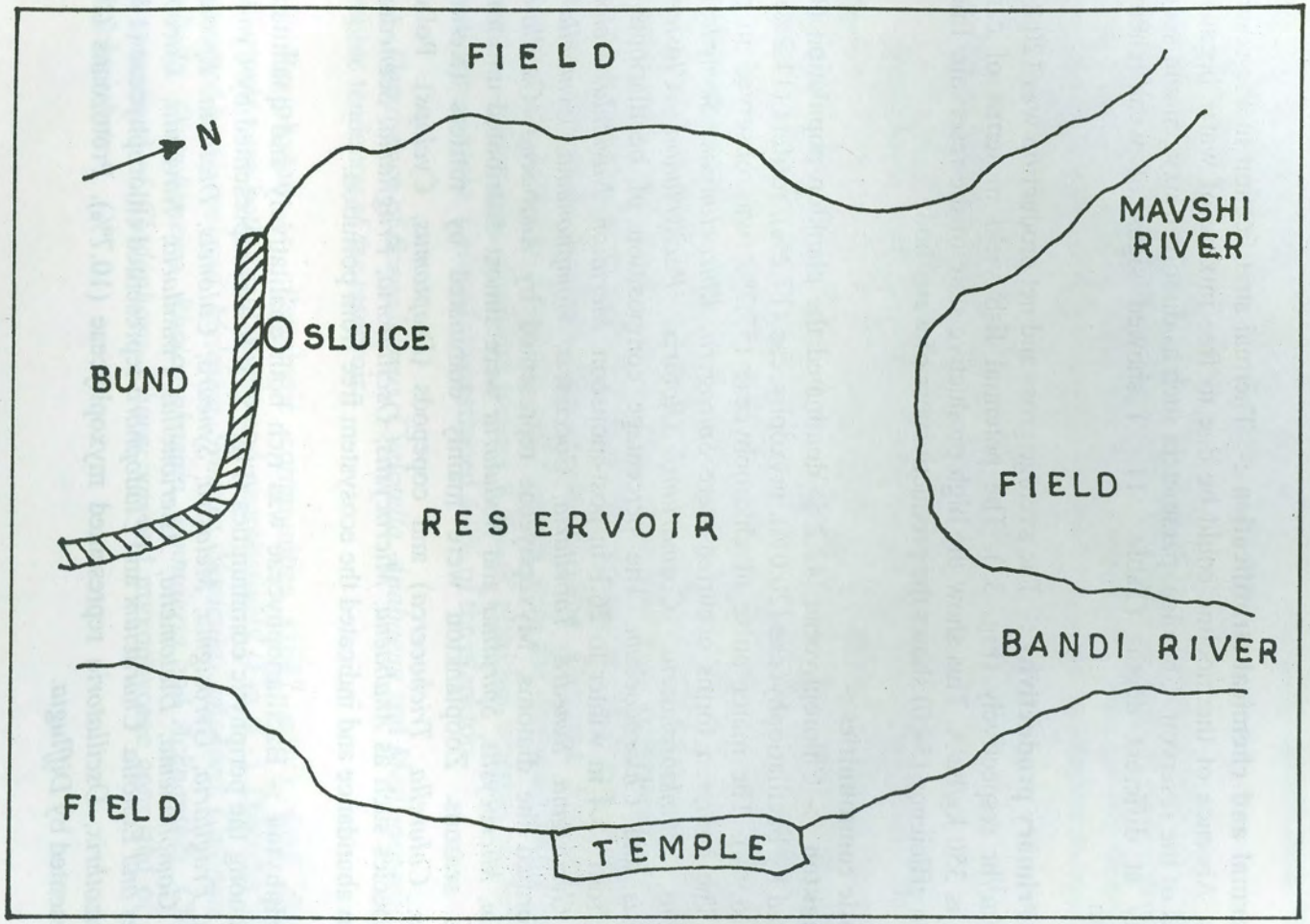


FIG 9 SCHEMATIC VIEW OF MAVSHI RESERVOIR

low to medium range respectively. Higher values of specific conductivity (946.0 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.

Thermal and chemical stratification :- Thermal stratification in the reservoir was absent. Absence of thermocline could be due to free mixing of water because of shallowness of the reservoir. Chemical parameters such as dissolved oxygen and specific conductivity at different depths (Table 11) showed signs of weak chemical stratification.

iii) Primary productivity :- The average gross and net production was 120.8 and 65.3 $mgC/m^2/hr$ respectively (Fig. 3). The potential fish yield in terms of carbon production is 350 kg/ha/A. This show the high productive state of the reservoir. Energy assimilation efficiency (54.0) shows the productiveness of water body.

7.5 Biotic communities :-

Plankton :- Chlorophyceae (42.2%) dominated the plankton population (1022 u/l) followed by bacillariophyceae (20.0%), myxophyceae (17.2%), rotifers (11.2%) and copepods (6.9%). The major pulse of chlorophyceae (57.7%) was observed in post-monsoon. The common forms occurred were *Spirogyra, Rhizoclonium, Scenedesmus, Botryococcus, Planktosphaeria, Cosmarium, Ulothrix, Pachycladon, Closterium, Characiopsis* and *Chlorococcum.* The percentage composition of bacillariophyceae fluctuated from 15.4 in winter to 26.1 in post-monsoon. *Meridion, Navicula, Melosira, Frustulia, Gyrosigma, Synedra, Tabellaria, Cocconeis, Gomphonema, Cymbella* and *Neidium* formed the diatoms. Myxophyceae represented by *Anabaena, Oscillatoria, Phormidium, Microcystis, Spirulina* and *Nodularia* were almost distributed uniformally in all the seasons. Zooplankton were mainly dominated by rotifers (*Keratella, Brachionus, Colurella, Trichocerca*) and copepods (*Diaptomus, Cyclops*). Pollution indicator species such as *Anabaena, Microcystis, Oscillatoria, Fragilaria, Scenedesmus* were less in abundance and indicated the ecosystem free from pollution.

Periphyton :- Bacillariophyceae was rich both qualitatively and quantitatively (69.9%), among the periphytic communities (Fig. 5). It was represented by *Cymbella, Tabellaria, Fragilaria, Gyrosigma, Melosira, Synedra, Caloneis, Diatoma, Epithemia, Amphora, Gomphonema, Diatomella, Asterionella, Pinnularia, Navicula, Cocconeis, Achnanthes and Eunotia. Characium* and *Cladophora* represented chlorophyceae (17.8%) while *Shcizothrix, Oscillatoria* represented myxophyceae (10.7%). Protozoans (1.6%) were represented by *Difflugia.*

Table 11 : Depth profile of Mavshi Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	31.0	26.0	18.0	9.2	8.7	7.2	5.6	9.2	8.8
2		26.0	18.0		8.6	7.1		8.8	8.0
4		25.5			8.6			8.4	
6		25.2			8.6			8.4	

Depth (m)	Total alkalinity (ppm)			Sp.conductivity (μmhos/cm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**
S	94	70	154	894	774	1170
2		70	152		766	1163
4		68			766	
6		68			766	

Macrobenthos :- The standing crop of macrobenthos was estimated as 750 u/m^2 (Table 6). Chironomids dominated the fauna (51.2%) followed by *Chaoborus* (17.7%), molluscs (17.7%) and tubificids (13.4%). The moderate level of macrobenthos among biotic communities may be due to low concentration of organic matter in the soil.

Macrovegetation :- The infestation of macrophytes in the reservoir was estimated as 1.42 kg/m^2 wet wt. (Table 7). The common forms of aquatic weeds occurred were *Potamogeton, Hydrilla* and *Vallineria*.

7.6 Fisheries :- During the year 1999-2000, a total of 68.4 t of fish landed from the reservoir yielding in a fish yield of 71.3 kg/ha. Indian major carps formed 53.2% of the total catch followed by cat fishes (36.0%) and other minor carps (10.8%). *L. rohita, C. catla* and *C. mrigala* formed 17.9, 17.8 and 17.5% of the total catch respectively. Besides Indian major carps, other fishes thriving in the reservoir are *W. attu, N. notopterus, C. marulius, L. gonius, G. gotyla, M. armatus* and *P. sarana*. The catch statistics indicate presence of good population of predators. The size of stocking therefore would be an important factor for better survival of major carps in the system.

7.7 Management :- 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 4.94 lakh of fingerlings of IMC (*L. rohita* 7.8, *C. mrigala* 5.5 and *C. catla* 86.7%) were stocked during the year 1994-95 to 1999-2000, averaging around 50 fingerlings/ha/A. The low fish yield inspite of high production potential thus could be due to low average stocking rate.

7.8 Recommendations :- The limnological investigations of Mavshi reservoir suggest high productive status of the water body having production potential of 350 kg/ha. The fish yield during 1999-2000, however, was 71.3 kg/ha which could be augmented significantly by adopting a judicious exploitation-cum-stocking policy. The reservoir has so far been poorly stocked (50 fingerlings/ha) and need stocking support. It is recommended that a stocking rate of 1050 fingerlings (50-75 mm) of mrigal , rohu and catla (3:2:2) per ha may be adopted for the reservoir. Further, gill nets of mesh bar 40, 50, 60, 75 mm may be used for fishing. In view of infestation of water body by aquatic weeds, the drag nets fishing in shallower areas would be more useful. Exploitation of the reservoir under the aegis of a co-operative society may prove beneficial to the local population from the fishery development programme. The various aspects of management of fisheries in reservoir be monitored carefully.

8. GUDA RESERVOIR

8.1 Location :- Guda reservoir is located at latitude 25°-26°N in the district of Bundi, Rajasthan. It lies in the Chambal river system (Fig. 10)

8.2 Morphometry :- Guda reservoir is fed with inflow from the river Mej. It has a water spread area of 1859 ha at FRL and a total catchment area of 744.9 km^2. The reservoir is mainly constructed for irrigation in the year 1958 and is surrounded by hills of Aravali ranges. The mean depth of 5.1 m suggest shallow character of the reservoir. The C/A ratio of 44 indicate more inputs of allochthonous nutrients through the catchment.

8.3 Meteorological observations :- The atmospheric temperature varied from 21.5 in winter to 35°C in summer.

8.4 Limnology and productivity :-

i) Physico-chemcial characteristics of soil :- The basin soil of the reservoir was silty-clay in texture (Table 2) and alkaline (pH 7.8) in reaction. Organic carbon (0.26%) and available phosphorus (3.6 mg/100g) were poor whereas available nitrogen (49.9 mg/100g) was in moderate range. The low phosphorus concentration in soil reflects rapid assimilation of available phosphorus in the biota.

ii) Physico-chemical characteristics of water :- Barring summer, the water of the reservoir remains clear imparting a greenish tinge. Transparency fluctuated from 41 cm in summer to 97 cm in post-monsoon. The water is alkaline (pH 8.0) which enable the normal ion-exchange of fresh water fishes. Dissolved oxygen ranged between 5.6 and 9.2 (av. 7.3) ppm. Free CO_2 was absent throughout the year. The seasonal variation in total alkalinity was quite discernible with minimum value in post-monsoon (72 ppm) and maximum in winter (146 ppm). The average total alkalinity (89.3 ppm) thus was conducive to fish productivity.

Calcium (25-39 ppm) and magnesium (7.2-11.4 ppm) content was of high order. Total hardness varied between 92 and 160 ppm. Chloride values fluctuated from 5.7 to 11.4 ppm. Dissolved organic matter an important parameter reflecting the productive nature of water varied from 1.5 to 9.6 (av. 5.2) ppm indicating high productive potential of the reservoir. Phosphate (0.02 ppm) and silicate (2.3 ppm) were of low to moderate range respectively. High values of specific conductivity (av. 306.0 μmhos/cm) corroborated the productive state of the reservoir.

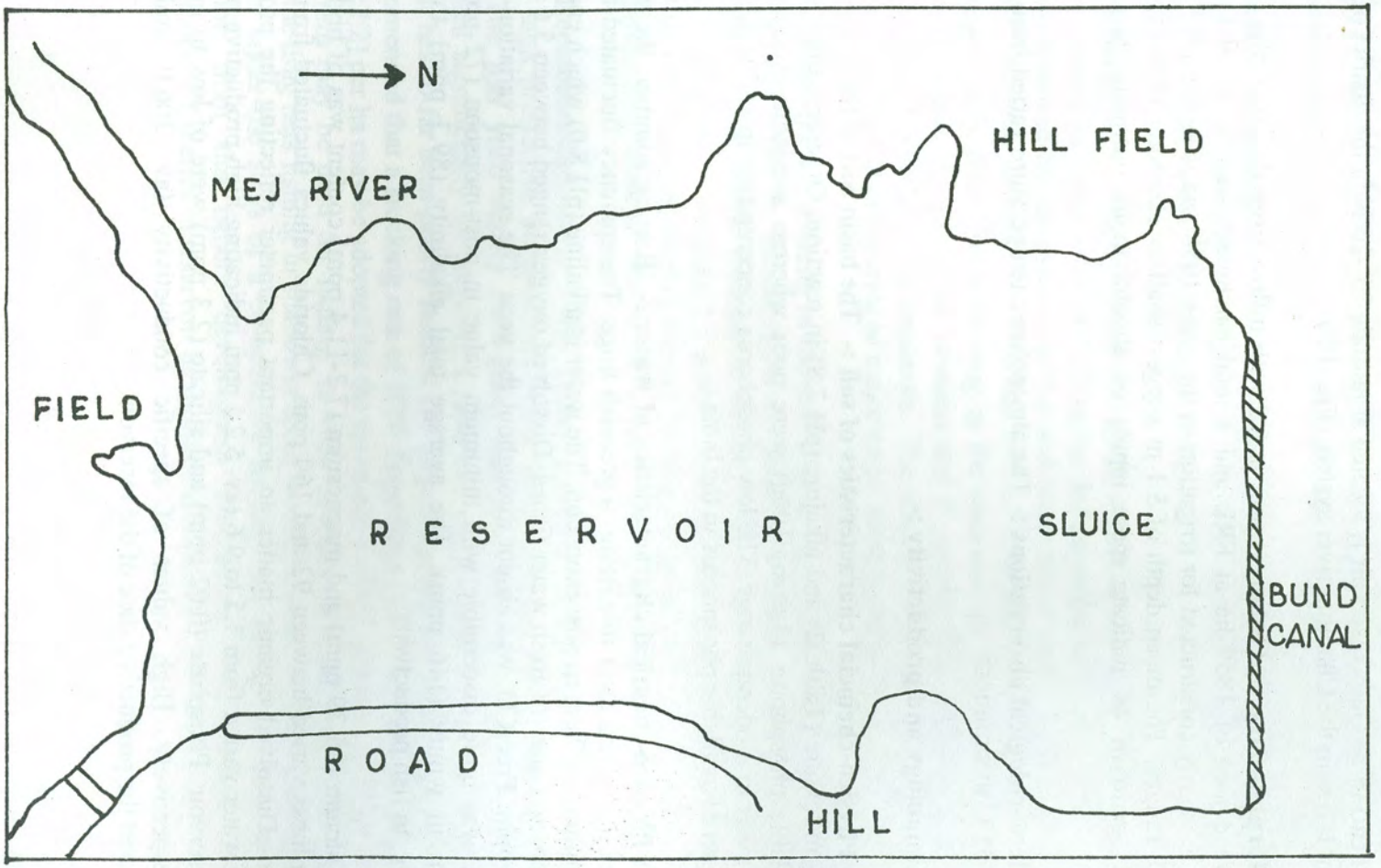


FIG. 10- SCHEMATIC VIEW OF GUDA RESERVOIR

Thermal and chemical stratification :- Water temperature difference from surface to 8 m depth (Table 12) never exceeded beyond 1°C and thus showed nearly isothermal condition. Mixing of water because of shallow reservoir might have prevented the formation of thermocline. Chemical parameters like dissolved oxygen, total alkalinity and specific conductivity showed signs of weak chemical stratification. Though the reservoir is productive , the oxycline is not so strong.

iii) Primary productivity :- The average gross and net production was 169.4 and 112.5 $mgC/m^2/hr$ respectively. The potential fish yield in terms of carbon production was estimated as 495 kg/ha/A. This shows high productive state of the reservoir. Energy assimilation efficiency (66.4) also place the reservoir in the productive category.

8.5 Biotic communities :-

Plankton :- Plankton abundance (av. 1179 u/l) fluctuated from 748 u/l in post-monsoon to 1399 u/l in winter. Chlorophyceae comprised 51.6% of the total (Fig. 4) plankton and were represented by *Spirogyra, Rhizoclonium, Scenedesmus, Botryococcus, Planktosphaeria, Characium, Chlorococcum, Troschiscia, Pediastrum, Cosmarium, Ulothrix, Characiopsis* and *Tetradon*. Its major pulse was observed during winter (66%). Myxophyceae formed 20.3% of the total plankton and was mainly represented by *Oscillatoria, Phormidium, Coccochloris, Microystis* and *Spirulina*. Maximum percentage of this group was recorded in post-monsoon. The percentage composition of bacillariophyceae varied from 7.0 in post-monsoon to 14.2% in winter. *Meridion , Navicula, Melosira, Frustulia, Gyrosigma, Synedra, Diatoma, Fragilaria Tabellaria, Cocconeis, Eucocconeis, Cymbella* and *Neidium* were the dominant forms in this group. Copepods (*Diaptomus, Cyclops*) formed 8.3% of plankton whereas rotifers (*Keratella, Brachionus, Filinia, Colurella*) constituted 4.9% of the plankton.

Occurrence of *Scenedesmus, Cyclotella, Anabaena* and *Merismopedia* showed the eutrophic tendency of the reservoir.

Periphyton :- Periphytic communities (1617 u/m^2) were dominated by bacillariophyceae both qualitatively and quantitatively (Fig. 5). Diatoms (65.4%) were represented by *Gyrosigma, Melosira, Synedra, Navicula, Amphora, Caloneis, Tabellaria, Cymbella, Gomphonema, Rhoicosphaenia, Pinnularia* and *Achnanthes*. Chlorophyceae was comprised of *Cladophora, Characium* and myxophyceae consisted of *Oscillatoria* and *Schizothrix*.

Table 12 : Depth profile of Guda Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	30.0	25.0	16.0	8.3	8.1	7.7	5.6	9.2	7.2
2	30.0	25.0	16.0	8.3	8.1	7.8	5.2	8.8	6.4
4	30.0	24.5	15.5	8.3	8.2	7.9	5.0	8.8	6.0
6	-	24.5	-	-	8.2	-	-	8.8	-
8	-	24.0	-	-	8.3	-	-	8.4	-

Depth (m)	Total alkalinity (ppm)			Sp.conductivity (μmhos/cm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**
S	72	50	146	426	197	295
2	76	50	152	425	205	320
4	76	48	156	425	189	327
6	-	48	-	-	192	-
8	-	48	-	-	197	-

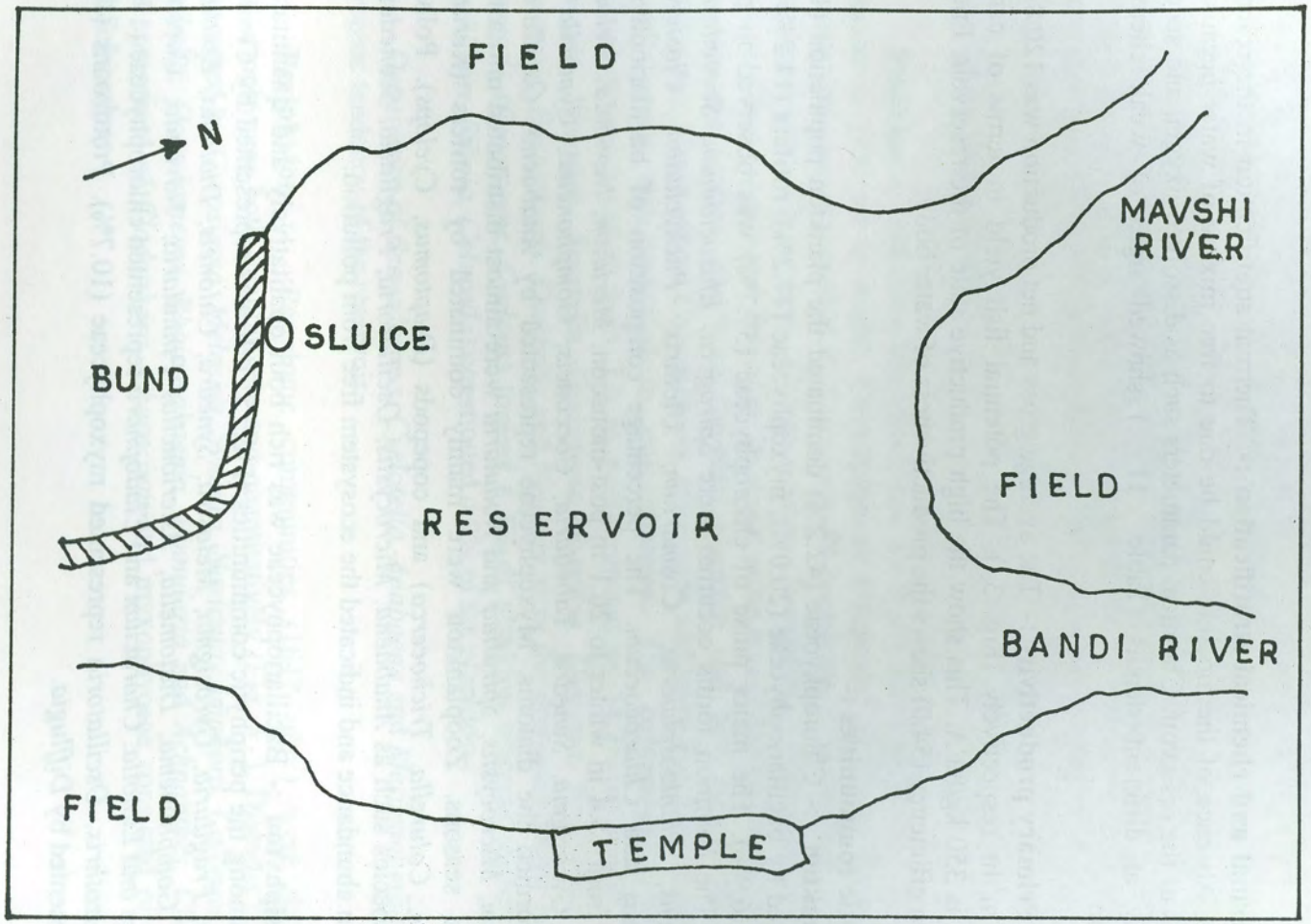


FIG 9 SCHEMATIC VIEW OF MAVSHI RESERVOIR

Macrobenthos :- The standing crop of benthic macrofauna was estimated as 866 u/m^2 (Table 6). Chironomids dominated the fauna (65.5%) followed by molluscs (17.3%) and *Chaoborus* (13.5%). Maximum concentration of benthos were in winter season.

Macrovegetation :- The density of aquatic weeds ranged from 0.3 kg/m^2 in summer to 0.7 kg/m^2 in winter showing an average 0.33 kg/m^2 wet wt. (Table 7). The common forms of macrophytes observed were *Hydrilla, Vallisneria* and *Potamogeton.*

8.6 Fisheries :- A total of 33.2 t of fish landed from all over the reservoir during the period April,99 to February,2000, yielding in a fish yield of 32.5 kg/ha. Indian major carps formed 65% of the total catch followed by cat fishes (18%) and other minor carps (17%). Besides Indian major carps, *L. bata, W. attu, N. notopterus, L gonius, C, reba, P. sarana, O. bimaculatus, M. vitatus* and *M. armatus* were the species thriving in the reservoir. 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.

8.7 Management :- Fishing in the reservoir is being conducted by fishing parties engaged by contractor to whom the fishing rights are leased out for a period of three years through open auction. All the inputs like gill-nets, drag-nets and hook and lines are provided by the contractor. Stocking policy is confined to the release of fingerlings of Indian major carps @ 500/ha.

8.8 Recommendations :- The limnological investigations of Guda reservoir suggest the high productive status of the water body with an estimated production potential of 495 kg/ha. In view of the present annual yield of 32.5 kg/ha, the fish production from the reservoir can be augmented significantly by adopting a judicious exploitation-cum-stocking policy. The reservoir has so far been stocked at an average of 840 fry per hectare during 1994-95 to 1998-99. Based on the production potential of 495 kg/ha, it is suggested that a stocking rate of 1480 fingerlings (50-75 mm) of mrigal, rohu and catla (3:2:2) per hectare may be adopted. Gill nets of mesh bar 40, 50, 60, 75 mm may be used for fishing. Considering the infestation of water body by aquatic weeds, the drag nets fishing in shallower areas would be more useful. Exploitation of the reservoir under the aegis of a co-operative society may prove beneficial to the local population from the fishery development programme. The various aspects of management of fisheries in the reservoir be monitored carefully.

9. MANSAROVAR RESERVOIR

9.1 Location :- Mansarovar reservoir is situated at latitude 25°-26'N in the district of Swai Madhopur, Rajasthan and lies in the Chambal river basin (Fig. 11).

9.2 Morphometry :- Mansarovar is fed with the rivers Kundaly and Galandy. It was constructed in the year 1952 for irrigation purposes. The reservoir is surrounded by hills of Aravali ranges and has a water spread area of 306 ha at FRL and a total catchment area of 35 km^2. The C/A ratio of 11.4 indicate low inputs of allochthonous nutrients through the catchment. The mean depth of 5.0 m suggest shallow character of the reservoir.

9.3 Meteorological observations :- The atmospheric temperature fluctuated from 18 in winter to 31°C in post-monsoon.

9.4 Limnology and productivity :-

i) Physico-chemical characteristics of soil :- The basin soil was sandy loam in texture (Table 2) and alkaline (pH 7.5) in reaction. The soil was deficient with regards to organic carbon (0.25%) and available phosphorus (2.5 mg/100g). The low phosphorus concentration in the soil reflects rapid assimilation of available phosphorus in the biota. Available nitrogen (40.5 mg/100g), however, was of moderate level.

ii) Physico-chemical characteristics of water :- Transparency of water in Mansarovar fluctuated from 41 cm in summer to 100 cm in post-monsoon. Shallowness of the reservoir coupled with high wind action in summer affected the transparency. The water temperature was lowest in winter (16°C) while it was maximum in summer (30°C). The wide fluctuation in the water temperature had a great bearing on the heat cycle of the reservoir. The water was alkaline (pH 7.9) in reaction which enables the normal ion-exchanges of fresh water fishes. Dissolved oxygen varied from 4.8 to 11.2 (av. 8.3) ppm. Free CO_2 was absent in summer and winter while it appeared at 3.0 ppm concentration in post-monsoon. The seasonal variation in total alkalinity was quite discernible with minimum value in post-monsoon (40 ppm) and maximum in winter (136 ppm). The average total alkalinity (88.7 ppm) indicated conduciveness of water body for higher fish productivity.

VIEW OF MANSAROVAR RESERVOIR

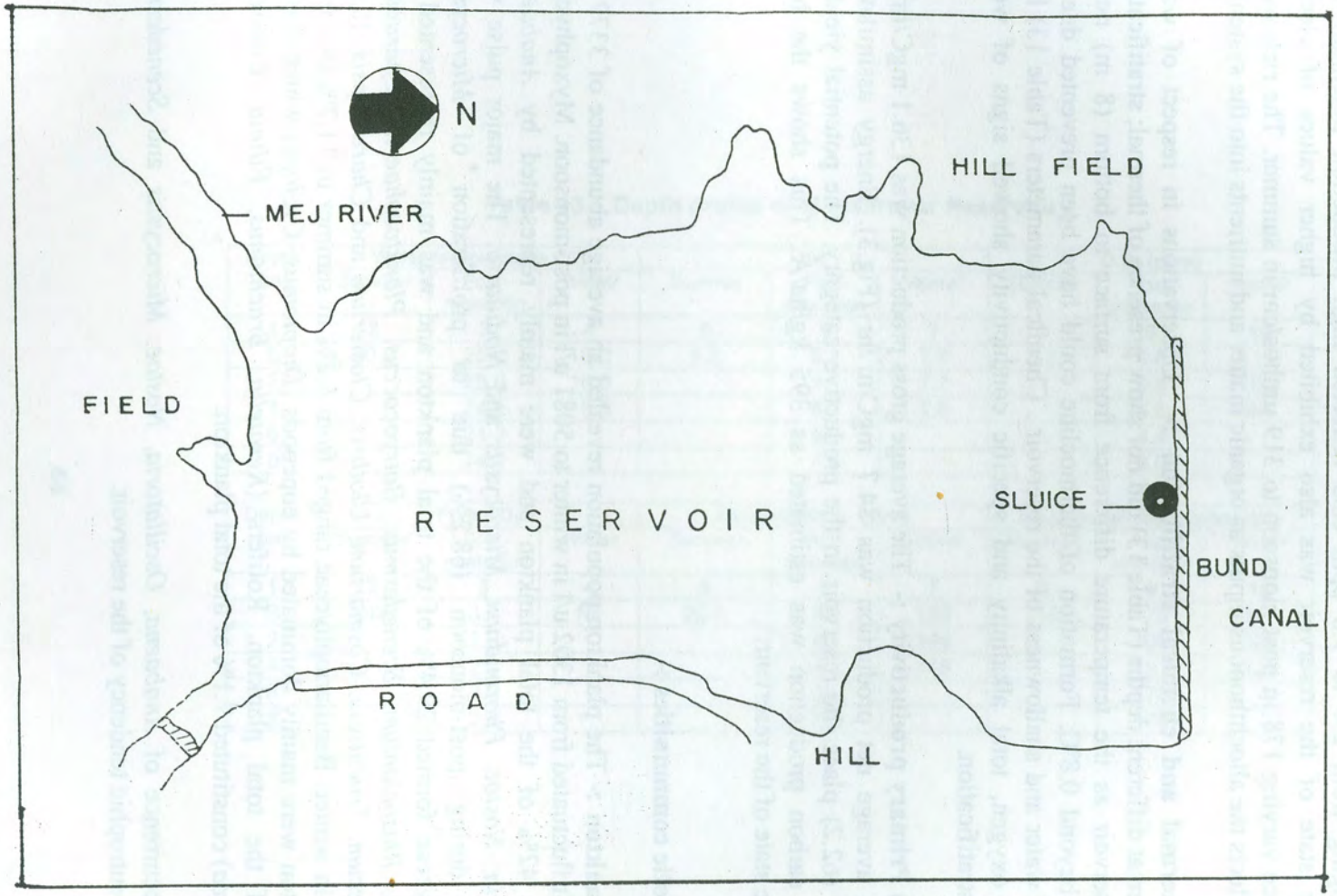


FIG. 10,- SCHEMATIC VIEW OF GUDA RESERVOIR

The productive nature of the reservoir was also evident with the higher value of calcium (29.5 ppm) and magnesium contents (11.4 ppm) of water. Dissolved organic matter ranging from 2.4 to 9.6 ppm also reflected high production potential. The productive state of the reservoir was also exhibited by higher values of electric conductance varying 178 in post-monsoon to 319 µmhos/cm in summer. The rich water quality reflects the allochthonous inputs as organic matter and nutrients into the system.

Thermal and chemical stratification :- Observations in respect of water temperature at different depths (Table 13) did not show presence of thermal; stratification in the reservoir as the temperature difference from surface to bottom (8 m) never exceeded beyond 0.8°C. Formation of thermocline could have been prevented due to mixing of water and shallowness of the reservoir . Chemical parameters (Table 13) like dissolved oxygen, total alkalinity and specific conductivity showed signs of weak chemical stratification.

iii) Primary productivity :- The average gross production was 136.1 $mgC/m^2/hr$ while the average net production was 84.7 $mgC/m^2/hr$ (Fig.3). Energy assimilation efficiency (62.2) place the reservoir in the productive category. The potential yield in terms of carbon production was estimated as 395 kg/ha/A. This shows the high productive state of the reservoir.

9.5 Biotic communities :-

Plankton :- The plankton population revealed an average abundance of 3377 u/l (Fig. 4). It fluctuated from 1302 u/l in winter to 5081 u/l in post-monsoon. Myxophyceae constitute 42% of the total plankton and were mainly represented by *Anabaena, Oscillatoria, Nostoc, Phormidium, Microcystis* and *Nodularia*. The major pulse was observed during post-monsoon (68.2%) due to proliferation of *Microcystis*. Chlorophyceae formed 29.4% of the total plankton and was mainly represented by *Spirogyra, Rhizoclonium, Scenedesmus, Botryococcus, Planktosphaeria, Characium, Chlorococcum, Trochiscia, Cosmarium, Ulothrix, Closterium* and *Characiopsis*. It was abundant in winter. Bacillariophyceae ranged from 5.2% in summer to 11.2% in winter. Zooplankton were mainly dominated by copepods (*Diaptomus, Cyclops*) which formed 10.4% of the total plankton. Rotifers (*Keratella, Brachionus, Filinia, Colurella, Trichocerca*) constituted 7.1% of the total plankton.

Occurrence of *Anabaena, Oscillatoria, Nostoc, Microcystis* and *Scenedesmus* indicated eutrophic tendency of the reservoir.

Table 13 : Depth profile of Mansarovar Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	30.0	25.0	16.0	7.8	8.1	7.8	4.8	8.8	11.2
2		25.0	16.0		8.1	7.7		8.8	10.0
4		24.5	15.5		8.1	7.6		8.6	9.6
6		24.2			8.0			8.4	
8		24.2			7.9			8.0	

Depth (m)	Free CO_2			Total alkalinity (ppm)			Sp.conductivity (μmhos/cm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	Nil	3.0	Nil	90.0	40	136	210	178	319
2		2.0			40	146		190	326
4		2.0			40	148		181	326
6		2.0			38			178	
8		2.0			36			176	

Periphyton :- Periphytic communities (1746 u/cm^2) were dominated by bacillariophyceae both qualitatively and quantitatively (71.9%; Fig. 5). Diatoms were represented by *Synedra, Gomphonema, Navicula, Nitzschia, Gyrosigma, Cymbella, Tabellaria, Frustulia, Fragilaria, Eunotia, Caloneis,Meridion, Achnanthes, Melosira, Hantzschia* and *Amphora*. Chlorophyceae (13.2%) was composed of *Characium. Cladophora* and myxophyceae (11.1%) was comprised of *Schizothrix* and *Oscillatoria.* Protozoans were represented by *Difflugia*.

Macrobenthos :- The benthic macrofauna was estimated as 2716 u/m^2 (Table 6). Chironomids (85.9%) dominated the fauna followed by molluscs (6.1%) and *Chaoborus* (4.3%). The concentration of benthos fluctuated from 650 in post-monsoon to 6550 u/m^2 in winter.

Macrovegetation :- Mansarovar has irrigated land all around consisting of very good level of nutrients due to which a variety of vegetation was noticed. The dominant forms were *Hydrilla, Vallisneria* and *Potamogeton*. The density of aquatic weeds ranged from 0.64 kg/m^2 in winter to 1.0 kg/m^2 in post-monsoon showing an average of 0.79 kg/m^2 wet wt. (Table 7).

9.6 Fisheries :- During the year 1999-2000, 45.6 t of fish landed from the reservoir yielding in a fish yield of 248 kg/ha. Indian major carps constituted 45.4% of the total catch followed by cat fishes (19.4%) and other minor carps (35.2%). *C. catla, L. rohita, L. calbasu, M. seenghala, C. reba, W. attu, L. gonius, P. sarana* and *L. bata* are reported from the reservoir.

9.7 Management :- The available records shows that the reservoir was stocked with 20.72 lakhs of fish seed of catla (51.9%), rohu (37.6%) and mrigala (10.5%), during the period 1994-95 to 1999-2000. Thus, the average stocking rate was 1126/ha. The exploitation in the reservoir is being conducted by fishing parties engaged by the contractor to whom the fishing rights were leased out against an open auction on three years terms basis. The main fishing gears which were operated in the reservoir are gill-nets, hook and lines and drag-nets.

9.8 Recommendations :- Limnological investigations of Mansarovar reservoir revealed high productive potential (395 kg/ha) against which the annual yield achieved was 248 kg/ha. The exploitation efficiency an index to assess the extent of utilization of net energy fixed by producers as fish is quite high (0.63%). The fish production can further be enhanced by adopting better management measures. Considering the biogenic capacity of the reservoir, stocking @ 1200 fingerlings/ha of mrigala 3,rohu,2 and catla 2 in the size range of 50-75 mm is recommended. Gill-nets of mesh bar 40,50,60,75 mm is recommended. Hooks and line fishing may be taken up for control of predators (*W. attu* and *M. seenghala*).

10 SILISHED RESERVOIR

10.1 Location :- Silished reservoir is situated around 10 km away from Alwar town and is surrounded by Aravali hills covered with dense forest. It was constructed by blocking the river Seeravas in the year 1845 mainly for irrigation. It lies in the Banas river system (Fig.12).

10.2 Morphometry :- The reservoir has a water spread area of 306 ha at FTL and a total catchment area of 136.7 km^2. The C/A ratio of 49.7 indicate higher inputs of allochthonous nutrients through the catchment. The mean depth (5.06 m) shows shallow nature of the reservoir.

10.3 Meteorological observations :- The atmospheric temperature varied from 18°C in winter to 32°C in summer.

10.4 Limnology and productivity :-

i) Physico-chemical characteristics of soil :- The basin soil of the reservoir is sandy loam in texture sand (49.7%) and silt (46.0%). The soil was deficient with regards to both organic carbon (0.28%) and available phosphorus (3.2 mg/100g). Available nitrogen (42.5 mg/100g) was of moderate range. The low phosphorus concentration in the soil reflects rapid assimilation of available phosphorus in the biota.

ii) Physico-chemical characteristics of water :- The water transparency fluctuated from 16 cm in summer to 61 cm in post-monsoon. Low transparency in summer may be attributed to shallowness of the reservoir coupled with high wind action. The water temperature ranged from 15.0 in winter to 29.0°C in summer. The alkaline water (pH 8.1) is favourable to fish growth. Dissolved oxygen varied from 4.8 to 10.0 ppm. Free CO_2 was absent during all the seasons. The seasonal variation in total alkalinity was quite discernible with minimum value in post-monsoon (70.0 ppm) and maximum in winter (110.0 ppm). Assessment of the productivity based on total alkalinity (84 ppm) reflected the water body fairly productive.

Calcium content of water ranged between 23.0 and 42.0 ppm. Magnesium concentration was of high range (15.6-19.8 ppm). Chloride values varied from 8.5 to 17.0 ppm. High values of organic matter (6.4-11.6 ppm) reflected high productive potential of the reservoir. Phosphate (0.03 ppm) and silicate were of low to medium range respectively. Higher values of specific conductivity (330-510 μmhos/cm) supported the eutrophic character of the reservoir. The rich water quality reflects the transport of allochthonous dissolved nutrients and their leaching into the system.

Thermal and chemical stratification :- Water was isothermal (Table 14), could be 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.

iii) Primary productivity :- The average gross and net production was 116.7 and 70.8 $mgC/m^2/hr$ respectively (Fig. 3). Energy assimilation efficiency (60.7) place the reservoir in the productive category. The potential fish yield in terms of carbon production was estimated as 340 kg/ha/A. This shows the high productive character of the reservoir.

10.5 Biotic communities :-

Plankton :- The plankton population revealed an average abundance of 3125 u/l (Fig. 4). It fluctuated from 1223 u/l in post-monsoon to 6372 u/l in winter. Chlorophyceae comprised 30.8% of the total plankton and were mainly represented by *Rhizoclonium, Scenedesmus, Botryococcus, Chlorococcum, Ankistrodesmus, Pediastrum, Cosmarium, Closterium, Characiopsis* and *Chrorella*. Myxophyceae constituted 25.6% of population and were represented by *Anabaena, Oscillatoria, Phormidium, Microcystis* and *Nodularia. Nodularia* had showed maximum concentration in winter in Silished reservoir. The percentage composition of bacillariophyceae ranged from 9.3 in post-monsoon to 27.5% in winter. Zooplankton were mainly dominated by rotifers (*Keratella, Brachinous, Filinia, Colurella*) forming 13.5% of the total plankton.

Occurrence of *Anabaena, Oscillatoria, Microcystis, Scenedesmus* and *Pediastrum* indicated eutrophic tendency of the reservoir.

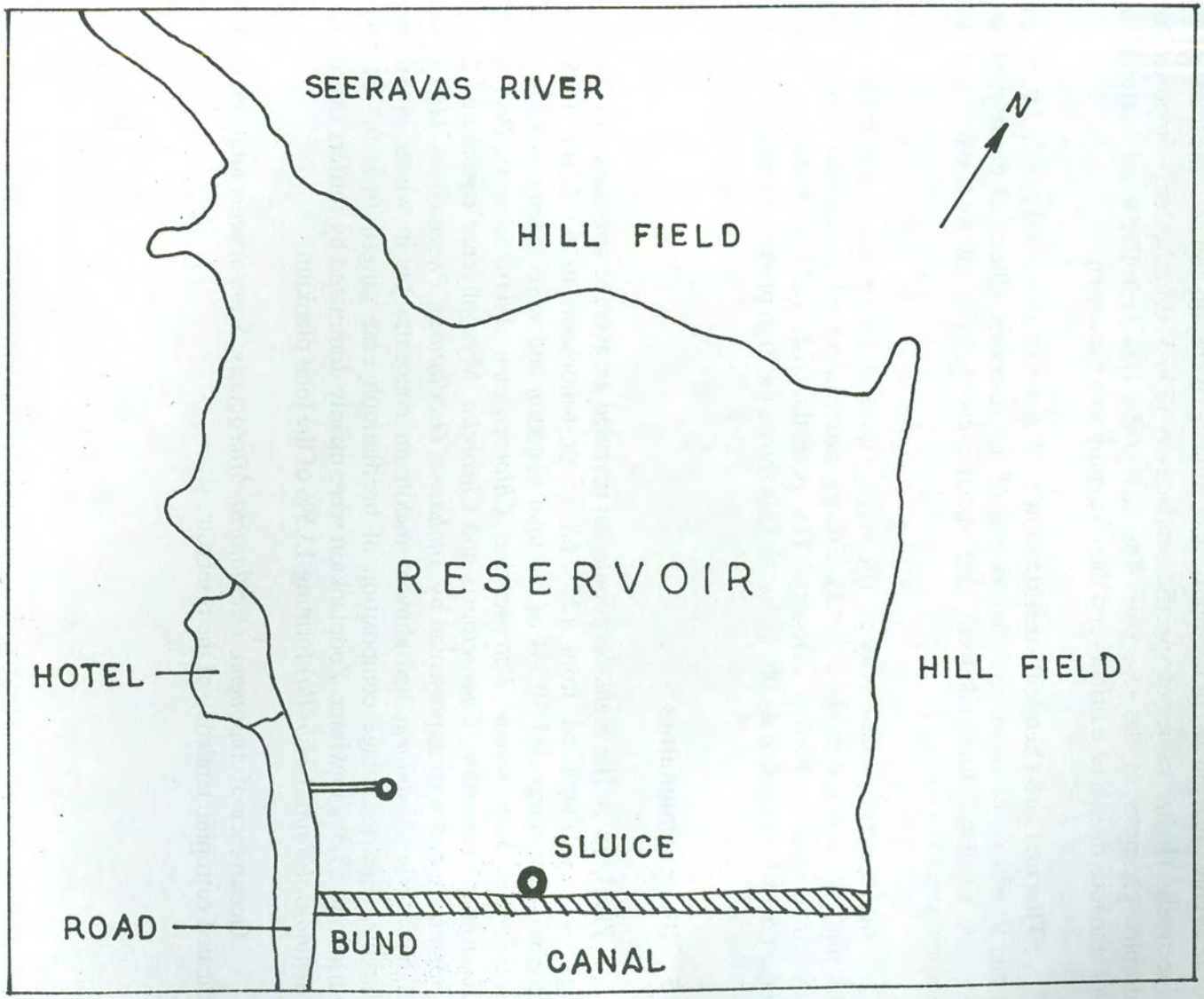


FIG.12-SCHEMATIC VIEW OF SILISHED RESERVOIR

Table 14 : Depth profile of Silished Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S	29.0	22	15	7.8	7.6	8.8	4.8	9.2	10.0
2		22			7.7			8.8	
4		22			7.8			8.8	

Depth (m)	Total alkalinity (ppm)			Sp.conductivity (μmhos/cm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	**2**	**3**	**4**	**5**	**6**	**7**
S	72	70	110	510	330	336
2		70			335	
4		72			335	

Periphyton :- Periphytic communities (1875 u/cm^2) were dominated by bacillariophyceae (70.8%, Fig. 5). Diatoms were represented by *Synedra, Gomphonema, Navicula, Cymbella, Tabellaria, Caloneis, Gryosigma, Nitzschia, Diatoma, Amphora* and *Pinnularia*. Chlorophyceae (13.9%) was comprised of *Characium, Cladophora* while myxophyceae (12.0%) was consisted of *Schizothrix* and *Oscillatoria*. Protozoans were represented by *Difflugia.*

Macrobenthos :- The standing crop of bottom macrofauna was estimated as 750 u/m^2 (Table 6). Chironomids constituted 60% of the total fauna followed by *Chaoborus* (17.7%), molluscs (13.3%) and tubificids (8.9%). Maximum concentration of benthos were recorded in winter.

Macrovegetation :- The macrophytes were absent in the Silished reservoir.

10.6 Fisheries :- During the year 1999-2000, 60.2 t of fish landed from the reservoir yielding in a fish yield of 365 kg/ha. Indian major carps constituted 50.2% of the total catch followed by cat fishes (29.9%) and other minor carps (19.9%). *C. catla* dominated catch. Besides Indian major carps, *M. seenghala, N. notopterus, W. attu, C. mrigala, M. armatus* and *Puntius sp.* were reported to thrive in the reservoir.

10.7 Management :- The available records shows that the reservoir was stocked with 22.98 lakhs of fish seed during the period 1994-95 to 1999-2000. Thus, on an average, the stocking rate was 1393/ha.

10.8 Recommendations :- Silished reservoir falls under productive category and the production from this reservoir (365 kg/ha) during 1999-2000 has crossed the level of projected fish potential (340 kg/ha). Exploitation of the reservoir under the aegis of a co-operative society may prove beneficial to the local population from the view of development programme in the area. Stocking of Indian major carps fingerlings in the size range of 50-75 mm and ratio of catla 3 : rohu :2 mrigala :2 may be stocked @ 1000 numbers per ha. The various aspects of management of fisheries in reservoir viz. Limits of fishermen number, fishing gear, catch characteristics and closed season may be monitored for optimum sustained utilization of the reservoir and for economic returns.

11. PANCHNA RESERVOIR

11.1 Location :- Panchna reservoir is situated at latitude 26^0-33'N in the Karoli district of Rajasthan. It lies in the Gambhiri river basin (Fig. 13).

11.2 Morphometry :- The reservoir has a water spread area of 1240 ha at FRL and a total catchment area of 621.6 km^2. It falls under the medium reservoir category. Bhadravati, Berkheda and Bensavat are the three main rivers joining the reservoir. The maximum depth of reservoir is 11.52 m where as the mean depth is 4.8 m. The other salient features of morphometry are presented in Table 1.

11.3 Meteorological observations :- The atmospheric temperature varied from 21°C in winter to 35°C in post-monsoon. The average rain fall in the area is 107 cm.

11.4 Limnology and productivity :-

i) Physico-chemical characteristics of soil :- The basin soil of the reservoir was sandy loam in texture (Table 2). Soil was alkaline in reaction (pH 7.1) and was deficient with regards to organic carbon (0.39%) and available phosphorus (2.45 mg/100g). Available nitrogen (41.9 mg/100g) was of moderate range.

ii) Physico-chemical characteristics of water :- The water temperature was lowest in winter (19^0C) while it was highest in post-monsoon (33^0C) period. The water is alkaline (pH 7.7) which enable the normal ion-exchanges of fresh water fishes and is favourable for fish growth. Transparency fluctuated from 46 cm in summer to 95 cm in winter. Low transparency in summer may be attributed to shallowness coupled with high wind action. The high values in winter were probably due to low wind action leading to lesser disturbances. Dissolved oxygen ranged from 6.0 to 12.8 (av. 9.3) ppm (Table 3). Free CO_2 was absent in summer and had maximum value of 4.0 ppm in post-monsoon period. The seasonal variation in total alkalinity was quite discernible with minimum values in winter (122.0 ppm) and maximum values in summer (150.0 ppm). The water bodies having total alkalinity above 90.0 ppm are generally conducive to high fish productivity and thus Panchna reservoir could also be considered as a productive reservoir.

Calcium content of water varied from 22.1 to 32.0 ppm. Magnesium concentration was observed to be of medium order which ranged between 1.6 and 5.8 ppm. Chloride values fluctuated from 11.7 to 23.3 ppm. Organic matter is an important parameter reflecting the productive nature of the water. Its values ranged from 1.0 to 5.6 (av. 2.7) ppm. Values of organic matter thus reflected high productive potential of the reservoir . Phosphate (0.05 ppm) and silicate (1.4 ppm) were of moderate range. Specific conductivity ranging between 161.0 and 237.0 μmhos/cm showed the productive state of the reservoir.

Thermal and chemical stratification :- Depth-wise observations in respect to water temperature indicated the presence of thermal stratification between 5 and 6 and 6 and 7 m depth with the drop of temperature @ 1.0^{0}C from 33^{0}C to 32^{0}C and 32^{0}C to 31^{0}C respectively in the post-monsoon period. Chemical parameters (Table 15) like dissolved oxygen, pH, free CO_2, total alkalinity and specific conductivity showed signs of strong chemical stratification during post-monsoon.

iii) Primary productivity :- The primary productivity studies revealed an average gross production of 125.0 mgC/m^2/hr while the average net production as 70.83 mgC/m^2/hr (Fig. 3). Energy assimilation efficiency (56.0) showed productive state of the water body. The expected fish yield in terms of carbon production is 365 kg/ha/A which shows the medium productive state of the reservoir.

11.5 Biotic communities :-

Plankton :- The plankton population ranged from 745 u/l in summer to 1278 u/l in winter and had an annual average production of 994 u/l (Fig. 4). On an average, phytoplankton formed 89.0% of total plankton. Among phytoplankters, bacillariophyceae out numbered chlorophyceae and myxophyceae both in population density as well as in species diversity. Planktonic composition in respect of bacillariophyceae was 43.3%. The major pulse of diatoms was observed in post-monsoon (52.7%) whereas its minimum concentration (29.4%) was in summer months. Diatoms were comprised of the typical tropical forms viz. *Caloneis, Diatoma, Frustulia, Navicula, Stauroneis, Synedra, Meridion, Gomphonema, Cocconeis, Melosira, Tabellaria* and *Amphora*.

VIEW OF PANCHNA RESERVOIR

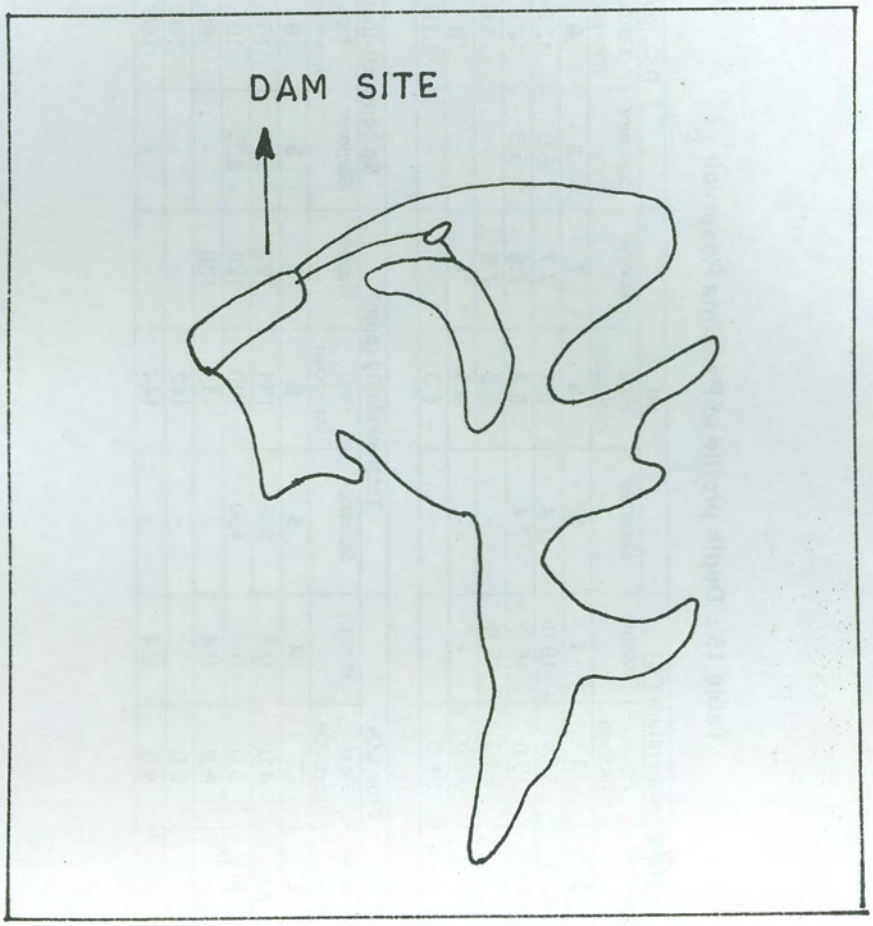


FIG.13-SCHEMATIC VIEW OF PANCHNA RESERVOIR

Table 15 : Depth profile of Panchna Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	2	3	4	5	6	7	8	9	10
S	31.0	33.0	19.0	7.4	8.1	7.7	6.0	12.8	9.2
2	31.0	33.0	19.0	7.4	8.2	7.6	5.6	12.0	8.6
4	-	33.0	19.0	-	8.2	7.6	-	11.6	8.2
6	-	32.0	-	-	8.3	-	-	10.4	-
8	-	31.0	-	-	8.3	-	-	10.0	-

Depth (m)	Free CO_2			Total alkalinity (ppm)			Sp.conductivity (μmhos/cm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	2	3	4	5	6	7	8	9	10
S	Nil	4.0	0.2	150	134	122	207	161	237
2	Nil	5.0	0.4	150	140	128	206	160	220
4	-	6.0	0.4	-	140	130	-	160	204
6	-	6.0	-	-	142	-	-	160	-
8	-	8.0	0.4	-	144	-	-	160	-

Myxophyceae constituted 19.1% of total plankton and was mainly represented by *Anabaena, Microcystis, Oscillatoria, Phormidium, Spirulina, Aphanocapsa* and *Coccochloris*. Chlorophyceae formed 17.9% of total plankton and were represented by *Schroederia, Rhizoclonium, Scenedesmus, Botryococcus, Cosmarium, Pediastrum* and *Pachycladon. Peridinium*, *Ceratium* and *Cystodinium* were also observed occasionally representing the group dinophyceae.

Among zooplankton, copepods (*Cyclops*, *Diaptomus* and nauplii) formed 5.9% of plankton followed by rotifers (*Brachionus, Keratella, Trichocerca, Colurella*; 4.9%), cladocerans (*Moina, Bosmina*, 2.5%) and protozoans (*Actinophrys, Actinosphaerium*, 2.8%).

Occurrence of pollution indicator species such as *Pediastrum, Caloneis, Tabellaria, Oscillatoria, Spirulina* and *Coccochloris* were less indicating the presence of more number of clean water indicator species among the phytoplankton community.

Periphyton :- Periphyton population ranged between 1649 and 1940 u/cm^2 . On an average, it was estimated as 1746 u/cm^2 (Fig. 5). Bacillariophyceae (77.4%) dominated over myxophyceae (13.1%) and chlorophyceae (7.5%). Bacillariophyceae was the richest qualitatively among the algae. It was represented by *Pinnularia, Gyrosigma, Amphora, Diatoma, Caloneis, Cymbella, Melosira, Synedra, Stauroneis, Tabellaria, Fragilaria* and *Cocconeis*. Chlorophyceae was composed of *Characium* and *Cladophora* where as myxophyceae flora were comprised of *Oscillatoria* and *Schizothrix*. *Difflugia* was the sole representative of protozoans.

Macrobenthos :- The standing crop of macrobenthos was estimated as 450 u/m^2(Table 6). It fluctuated from 300 u/m^2 in post-monsoon to 650 u/m^2 in winter. Chironomids dominated the fauna (70.4%) followed by *Chaoborus* larvae (11.1%) and molluscs (11.1%).

Macrovegetation :- Aquatic weeds occurred during summer season (0.9 kg/m^2 wet wt.; Table 7) only. The dominant form were *Hydrilla, Vallisneria* and *Potamogeton.*

11.6 Fisheries :- The reservoir has not been leased out for fishing in the year 1998-99. The exploitation in the reservoir was carried in the year 1995-96 by the fishermen engaged by the contractor to whom the fishing rights were leased out against an open auction. A total of 16.4 t of fish landed during the year yielding in a fish yield of 22.0 kg/ha. The species thriving in the reservoir are reported to be *C. catla, L. rohita, C. mrigala, M. seenghala* and *W. attu*. The main fishing gears which were operated in reservoir are gill-nets, hook and lines and drag-nets.

11.7 Management :- The available records shows stocking of 3.08 lakhs of fish seed of catla (4.5%), rohu (21.3%) and mrigal (54.2%) during the period 1994-95 to 1998-99. Thus, the average stocking rate has been computed as 50/ha.

11.8 Recommendations :-The limnological investigations of Panchna reservoir revealed high productive status of the water body with an annual yield of 22.0 kg/ha against the productive potential of 365 kg/ha. The exploitation efficiency an index to assess the extent of utilization of net energy fixed by producers as fish is very low (0.06%). The fish production can be enhanced significantly by adopting a judicious exploitation-cum-stocking policy.

Stocking policy is confined to the release of Indian major carps with out considering the biogenic capacity of the reservoir. The average stocking rate during the period 1994-95 to 1998-99 was 50/ha. Based on the potential fish yield of 365 kg per hectare, the average expected growth of 0.5 kg for each of the species of carps and an allowance of 50% loss due to predation the stocking rate will be 1100 numbers per hectare. The fish seed may be stocked in the ratio of mrigal 3, rohu 2 and catla 2. Further in the absence of herbivore fishes in the reservoir, the energy available from macrophytes is not transferred directly to higher trophic levels. This emphasises the need for stocking of suitable fish to utilize these vacant niches.

Gill-nets of mesh bar 40, 50, 60, 75 mm may be used for fishing. Drag-nets fishing in the shallower areas of the reservoir is more useful because of infestation of weeds. Hook and line fishing may be taken up for control of predators (*W. attu* and *M. seenghala*).

12. BARETHA RESERVOIR

12.1 Location :- Baretha reservoir is situated 50 km to south-west of Bharatpur town (Fig. 14). It was reconstructed by blocking the river Kakara by an earthen dam. The reservoir is surrounded by hills covered with dense forest. It was reconstructed in the year 1972. It lies in the Gambhiri river basin.

12.2 Morphometry :- The reservoir has a water spread area of 1006 ha at FRL and a total catchment area of 181.3 km^2. The mean depth of the reservoir is 5.21 m. It falls under medium reservoir category. The salient morphometric features are presented in Table 1.

12.3 Limnology and productivity :-

i) Physico-chemical characteristics of soil :- The basin soil of the reservoir is sandy loam in texture sand(69.5%) and silt (14.7%; Table 2). The soil was deficient with regards to both organic carbon (0.46%) and available phosphorus (2.5 mg/100g). The available nitrogen (45.2 mg/100g) was however of moderate range.

ii) Physico-chemical characteristics of water :- Transparency of water fluctuated from 44 cm in summer to 175 cm in winter. Shallowness of reservoir coupled with high wind action in summer affected the transparency. The high values in winter were probably due to low wind action leading to lesser disturbances. The temperature was lowest in winter (17.0°C) while it was maximum in post-monsoon (35°C) period (Table 16). The water was alkaline (pH 7.6) in reaction which enable the normal ion-exchanges of freshwater fishes and is favourable for fish growth. Dissolved oxygen varied from 8.8 to 12.0 (av. 10.2) ppm (Table 3). Free CO_2 ranged between 0.2 and 6.4 ppm. Total alkalinity fluctuated from 100.0 to 146.0 ppm. The average alkalinity values (125.3 ppm) indicated conduciveness of water body for higher fish productivity.

The productive nature of reservoir was also evident with the high values of calcium concentration varying between 26.3 and 35.3 ppm. Magnesium content was also of high order, ranging between 1.9 and 7.9 ppm. Values of total hardness varied from 92.0 to 112.0 ppm (Table 3). Chloride concentration fluctuated between 9.7 and 19.9 ppm. Dissolved organic matter is an important parameter reflecting the productive nature of water. It value from 1.2 to 6.0 ppm reflected high production potential. The productive state of the reservoir was also evident from the higher values of specific conductivity varying from108.0 in winter to 291.0 µmhos/cm in post-monsoon.

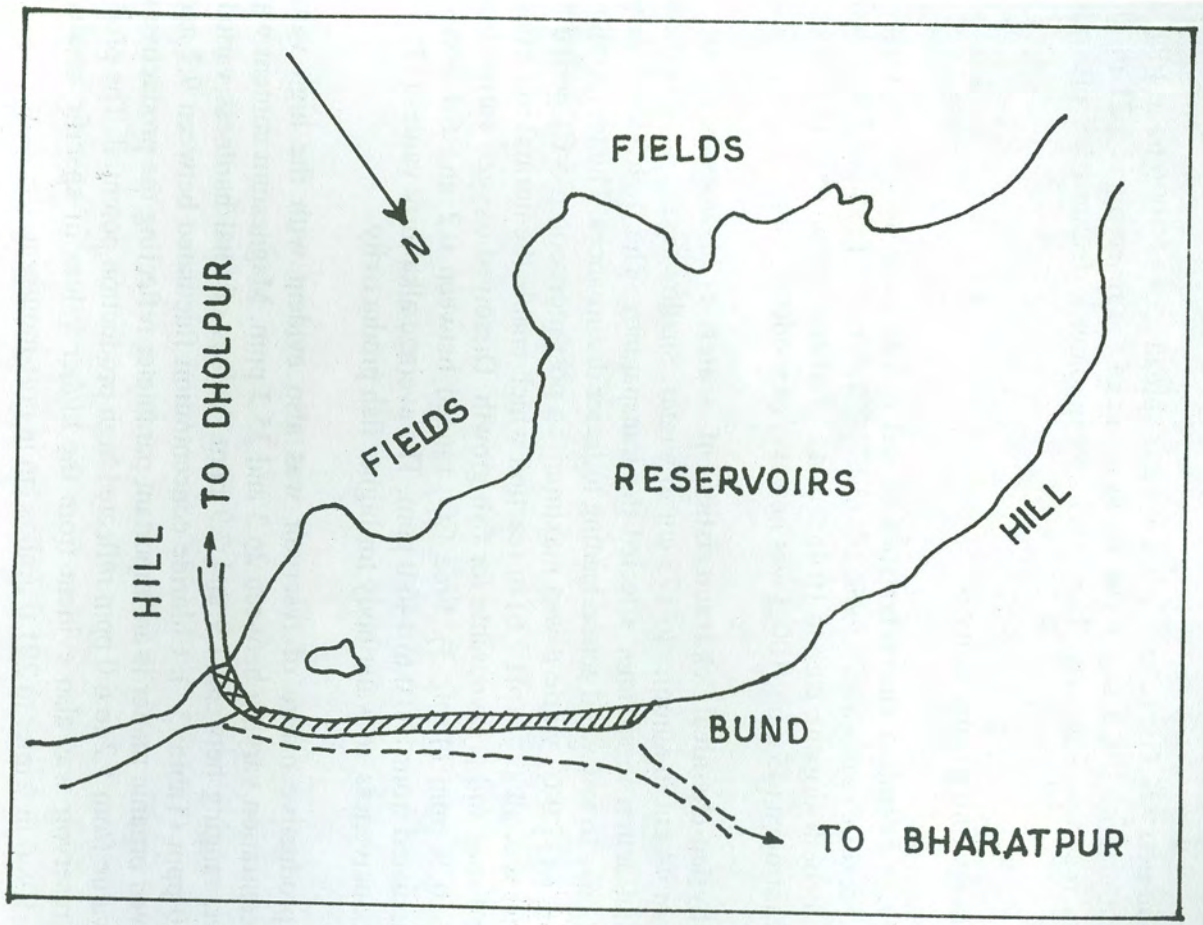


FIG.14- SCHEMATIC VIEW OF BARETHA ——— RESERVOIR

VIEW OF BARETHA RESERVOIR

Thermal and chemical stratification :- Depth-wise observation of water temperature indicated the presence of thermal stratification between 3 and 4 m depth with the drop of temperature @ 1.0°C from 35°C to 34°C and between 6 and 7 m with the drop of temperature @ 1.0°C from 34°C to 33°C in the post-monsoon period. Water bodies which stratify thermally are known to be productive. Chemical stratification in respect of dissolved oxygen, alkalinity, free CO_2, specific conductivity (Table 16) was also discernible.

The delineation of foregoing hydrological parameters clearly reflects the high productivity of Baretha reservoir. The rich water quality showed the transport of allochthonous dissolved nutrients and their leaching into the trophic cycling system.

iii) Primary productivity :- The gross carbon production ranged from 100.0 to 212.5 (av. 141.67) $mgC/m^2/hr$. The net production varied between 50.0 and 162.5 (av. 87.5) $mgC/m^2/hr$ (Fig. 3). Energy assimilation efficiency (62.0) revealed the productive state of the reservoir. The potential fish yield in terms of carbon production is estimated as 410 kg/ha.

12.4 Biotic communities :-

Plankton :- The plankton population of the reservoir fluctuated from 994 u/l in summer to 3279 u/l in post-monsoon . The increase in the abundance of plankton during post-monsoon was due to dominance of myxophyceae (88.0%) particularly by the proliferation in the population of *Microcystis*. On an average, myxophyceae formed 48.2% of the plankton population (Fig. 4) and was mainly represented by *Microcystis, Anabaena, Oscillatoria, Phormidium, Spirulina, Amphithrix, Aphanocapsa* and *Cocchocloris*. The list of plankton encountered during the period of investigation is given in Table 5.

Green algae were mainly comprised of *Schroederia, Rhizoclonium, Scenedesmus, Botryococcus, Cosmarium, Pediastrum* and *Pachyladon*. It constituted 33.7% of the total plankton. The major pulse of green algae was in winter (78.5%) whereas its minimum concentration was in post-monsoon months. Bacillariophyceae constituted 5.6% of the total plankton and was represented by *Cocconeis, Synedra, Frustulia,, Tabellaria, Navicula, Gyrosigma, Diatoma, Meridion, Melosira* and *Gomphonema. Peridinium, Ceratium* and *Cystodinium* represented the group dinophyceae (1.4%). Among zooplankton, copepods (*Diaptomus, Cyclops* and nauplii) formed 6.7% of the plankton followed by rotifers (*Brachionus, Keratella, Trichocerca* and *Colurella*; 3.7%).

Table 16 : Depth profile of Baretha Reservoir

Depth (m)	Water temperature (°C)			pH			D.O. (ppm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	2	3	4	5	6	7	8	9	10
S	28.0	35.0	17.0	7.4	7.4	7.8	8.8	12.0	9.8
2	27.5*	35.0	-	7.4	7.4	-	7.6	11.2	-
4	27.0	34.0	16.5	7.3	7.3	7.6	7.2	11.2	9.2
6	-	34.0	-	-	7.3	-	-	10.4	-
8	-	33.0	16.0	-	7.3	7.5	-	10.0	8.8

Depth (m)	Free CO_2			Total alkalinity (ppm)			Sp.conductivity (μmhos/cm)		
	Summer	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*	*Summer*	*Post-monsoon*	*Winter*
1	2	3	4	5	6	7	8	9	10
S	6.4	5.0	0.2	130	100	146	193.0	291	108.0
2	6.6	6.0	-	132	104	-	205.0	291	-
4	7.0	8.0	0.2	132	112	150	206.0	298	115.0
6	-	8.0	-	-	118	-	-	298	-
8	-	9.0	0.4	-	120	156	-	307	127.0

Periphyton :- Periphytic population ranged between 1746 and 1940 u/cm^2 .On an average, it was encountered as 1875 u/cm^2 (Fig. 5). Bacillariophyceae was rich both qualitatively and quantitatively (78.3%) and was represented by *Navicula, Pinnularia, Fragilaria, Synedra, Amphora, Diatoma, Melosira, Cymbella, Caloneis, Stauroneis, Eucocconeis, Tabellaria* and *Achnanthes. Characium, Cladophora* represented chlorophyceae (8.3%) while *Oscillatoria* and *Schizothrix* represented myxophyceae (13.3%).

Macrobenthos :- Macrobenthos of Baretha reservoir were dominated by chironomids (56.7%) followed by molluscs (35.1%). The average abundance of macrobenthos was of moderate level (617 u/m^2; Table 6). It ranged from 200 u/m^2 in summer to 1250 u/m^2 in winter . The low abundance of macrobenthos among the biotic communities may be due to limited concentration of organic matter in the soil.

Macrovegetation :- Macrophytes were estimated as 0.450 kg/m^2 wet wt. They were absent during post-monsoon period (Table 7). *Hydrilla, Vallisneria* and *Potamogeton* were the dominant forms observed during the period of study.

12.5 Fisheries :- A total of 81.9 t of fish landed from the reservoir during the period February,98 to December,98, yielding in a fish yield of 135.6 kg/11 months. Minor carps formed 43.8% of the total catch followed by *C. mrigala* (12.3%), *M. seenghala* (11.9%), *L. rohita* (9.8%), *W. attu* (8.9%), *Channa spp.* (9.9%) and *C. catla* (3.4%). The other fish species thriving in the reservoir are *O. bacaila, L. calbasu, C. reba, P. sarana. P. ticto, P. stigma, O. cotio, C. idella, O. bimaculatus, C. punctatus, C. marulius, A. nama, A. ranga, G. giuris* and *M. armatus.*

12.6 Management :- Contractor is expected to stock the reservoir @ 500 fish seed of IMC as per the guidelines provided by the Deptt. of Fisheries, Rajasthan.

Exploitation 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 against an open auction. The main fishing gears which are operated are fasla nets and hook and lines. Around 50 boats are being used for fishing by 100 fishermen. Conservation measures like not allowing the operation of nets below 38 mm mesh bar and the observance of a closed season from 15th June to 31st August have been implemented by the Department of Fisheries, Rajasthan.

12.7 Recommendations :-Limnological parameters like total alkalinity (125.3 ppm), calcium (30.1 ppm), dissolved organic matter (3.0 ppm) and specific conductivity (197.0 μmhos/cm) exhibited productive character of the reservoir.

Stocking policy adopted for the reservoir is confined to the release of Indian major carps fingerlings without paying adequate attention to the biogenic capacity of the ecosystem. Taking production potential of 410 kg of fish per hectare, an annual average growth of 0.5 kg for each fish of the species of carps stocked and giving allowance of 50% loss due to predation, the stocking rate will be 1200 numbers of fingerlings per hectare. These may be stocked in the ratio of mrigal 3, rohu 2 and catla 2. Further, in the absence of adequate number of herbivore fishes in the reservoir the energy available from macrophytes is not transferred directly to higher trophic levels. This emphasises the need of stocking of suitable fish preferably *C. idella* to utilize these vacant niches.

Gill-nets of mesh bar 40, 50, 60, 75 mm may be used for fishing , Drag-nets fishing in the shallower areas of the reservoir is more useful because of the infestation of weeds. Hook and line fishing may be taken up for control of predators (*W. attu* and *M. seenghala*). Exploitation of the reservoir under the aegis of a co-operative society may prove beneficial to the local population. The various aspects of management of fisheries in reservoir suggested in general for other reservoirs in the report may be monitored with perfection.

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