Ecology Based Fisheries Management in Small Reservoirs of Haryana



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Foreward

Reservoir fisheries resources are the most important component to eradicate malnutrition amongst rural poor and to generate employment for millions directly or indirectly. These reservoirs which have come up after independence in large numbers either to effect flood control and irrigation or to generate hydroelectric power, in addition to provide recreational activities through commercial tourism are important fisheries resources of the nation with potential to enhance fisheries production.

Keeping this in view two small man-made lakes near Delhi in Haryana viz. Badkhal lake and Peacock reservoir have been investigated to manage them on scientific line. It is hoped that the findings will be immense help in that direction.

D. Nath
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CONTENTS

1. INTRODUCTION

Harvesting the river resources for irrigation and hydroelectric power generation has been the main thrust of developmental activities all over the world and so is in India. Since Independence a large number of impoundments have came up in the country to water for irrigation purpose, flood control, domestic use and industrial purposes. There has been manifold increase in construction of dams in different river valley basins, leading to formation of many man made reservoirs. In some areas these reservoirs have come up purely for flood control. The fish production from Indian reservoirs is very low averaging about 20 Kg/ha (Sugunan, 1995) . These underutilised fishery resources offer immense scope and potential for generating additional national income of the order of Rs 1000 million per year by implementing Scientific management policies.

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

The All India Co-ordinated project on Ecology and fisheries of freshwater reservoirs initiated in 1971 has brought to focus the basic hypothesis regarding productive capacities of some large reservoirs of India. Badkhal and Pea Cock reservoirs are very small reservoirs near Delhi in Aravali Hills which are primarily meant for flood control and are being developed for tourism and fisheries by Haryana. The investigation carried out will help to evolve management plans capable of enhancing fish biomass in these reservoir.

2. SAMPLING PROCEDURE

Samples pertaining to limnobiological parameters were collected once in summer (March-June,1997), post-monsoon (Sept.- Oct., 1996) and winter (Jan.- Feb.,1997) seasons. The physico- chemical parameters of water were determined following the standard method given in APHA (1985). The analysis in respect of biological parameters were done as described by Jhingran et al., (1969).

3. BADKHAL RESERVOIR

3.1 Location and Morphometry

Badkhal reservoir is located 4km away from Fridabad. It is located at latitude 28°45' North and longitude 77°25' East. It is man made lake which came into existence in a george on Aravali ranges in Faridabad district of Haryana. The reservoir was mainly constructed to save the adjoining area of Faridabad and Delhi from floods and water stored is utilized for irrigation purposes. The tourist traction is harnessed by the Haryana Tourism Development Corporation which has well developed infrastructure for tourists. Location map of reservoir is illustrated in Fig. 1. Badkhal reservoir (22.8 ha. at FRL) is surrounded by

in surrounding hills, soil erosion has assumed enormous proportions which has risen the reservoir bed and their by reduced the capacity of the reservoir. The location and morphometric features of Badkhal reservoir is given in Table 1.

Table :1 Location and morphometric features of Badkhal Reservoir.

Parameters	Badkhal Reservoir
Latitude N	28°45'
Longitude E	77° 25'
Year of construction	1947-49
Length	644.3 m
Width	12.2 m
Top reservoir level	218.9 m
Full normal reservoir level	216.7 m
Creast R.L.	210.3 m
Capacity at FSL	286 ha m
Catchment area	11.9 sq. km

3.2 Meteorological and Hydrographical observations

The maximum reservoir level was 216.03 m while the minimum level was 212.74 m.

3.3 Limnology and productivity

Soil and water quality :- The bottom soil was highly sandy in texture (Table 2). The increase in percentage of sand from 63.5 to 96.5 during post-monsoon may be due to influx of rain water loaded with more sand from the catchment area. The overall high percentage of sand indicated poor water retention capacity of soil. Organic carbon was poor, while the concentration of available phosphorus (4.6 to 7.0 mg/100g) and available nitrogen (11.2 to 51.5 mg/100g) was of medium range.

Table : 2 Physico- chemical characteristics of soil of Badkhal Reservoir.

Parameters	Pre-monsoon	Post-monsoon
Sand (%)	63.50	96.50
Silt (%)	22.70	0.50
Clay (%)	13.80	3.00
pH	6.90	7.80
Organic carbon (%)	0.32	0.75
Free $CaCO_3$ (%)	1.35	0.09
Available phosphorus (mg/100g)	4.60	7.00
Available nitrogen (mg/100g)	51.50	11.20
Sp. conductivity (µmhos/cm)	358.0	

The minimum water temperature was recorded in winter (15.0°C) while the maximum temperature was in post-monsoon (31.2°C, Table 3). Average pH was 8.0 and thus reflected alkaline water conditions suitable

for fish growth. Transparency fluctuated from 4.5 in post-monsoon to 156.0 cm in winter. The high values in winter were probably due to low wind action leading to lesser disturbance. Dissolved oxygen ranged from 6.2 to 8.9 (av. 7.3) ppm. Free CO_2 was absent in winter and summer and appeared at the concentration of 10 ppm in post-monsoon. The seasonal variation in alkalinity was quite discernible with minimum values in post-monsoon and maximum values in summer. It ranged from 92.0 to 116.0 (av. 106.7) ppm. The water body having total alkalinity above 90.0 ppm are generally conducive to high fish productivity.

Calcium concentration moderate (19.24 to 20.04 ppm). Magnesium content was of high order, ranging from 12.81 to 13.31 ppm. Total hardness varied between 84.0 to 104.0 ppm. Chloride values fluctuated from 25.56 to 28.4 ppm. Organic matter is an important parameter reflecting the productive nature of water. It is value ranged from 2.0 to 8.2 (av. 6.1) ppm. Values of organic matter thus reflects high production potential of the reservoir. High values of specific conductivity ranging between 117.0 and 312.0 (av. 213.6) µmhos/cm were recorded. This also reflects the productive state of the reservoir.

Limnological investigations of Bad...al reservoir exhibited productive status of the water body which was evident from its limno-chemical parameters like total alkalinity (92.0-116.0 ppm), dissolved organic matter (2.0-8.0 ppm), calcium (19.24 to 20.4 ppm) and specific conductivity (117.0-312.0 µmhos/cm). The rich water quality reflects the transport of allochthonous dissolved nutrients and their leaching into the trophic cycling system.

Table : 3 Physico-chemical characteristics of surface water of Badkhal Reservior.

Parameters	Ranges	Average
Water temperature (°C)	15.0-31.2	24.7
Transparency (cm)	41.6-156.0	102.8
pH	6.8-9.0	8.0
Dissolved oxygen (ppm)	6.2-8.9	7.3
Free CO_2 (ppm)	Nil-10.0	3.3
HCO_3 (ppm)	92.0-116.0	106.7
Dissolved organic matter (ppm)	2.0-8.2	6.1
Hardness (ppm)	84.0-104.0	96.0
Calcium (ppm)	19.24-20.04	19.8
Magnesium (ppm)	12.81-13.31	13.0
Chloride (ppm)	25.56-28.4	26.9
Sp. conductivity (µmhos/cm)	117.0-312.0	213.6

Thermal and chemical stratification :- Depth-wise observations in respect of water temperature (Table 3) did not show thermal stratification . The reservoir water in summer had a maximum difference of 0.5°C from surface (28.0°C) to 2 m (27.5°C) while it had a maximum difference of 2.2°C in monsoon, from 31.2 at surface to 29.0°C at 5 m depth. Chemical parameters (Table 3) , particularly total alkalinity (92.0 at surface to 136.0 ppm at 5 m depth in post-monsoon) and specific conductivity (117.0 at surface to 270.0 µmhos/cm at 5 m depth in post-monsoon) showed signs of strong chemical stratification indicating productive nature of the ecosystem.

Depth	Water temp. (°C)			pH			D.O.(ppm)		
(m)	Post-mon	Winter	Summer	Post-mon	Winter	Summer	Post-mon	Winter	Summer
S	31.2	15.0	28.0	9.41	6.82	7.93	8.96	6.2	6.88
1	31.0	15.0	28.0	9.10	6.90	8.02	8.60	6.2	6.88
2	31.0	15.0	27.5	8.26	6.90	8.15	2.72	6.2	-
3	30.8	15.0	Depth	7.85	7.02	-	0.96	6.0	-
4	29.8	14.3	Not	7.63	7.02	-	0.64	6.0	-
5	29.0	-	available	7.31	-	-	0.32	-	-

Depth	Free CO_2 (ppm)			Total alkalinity (ppm)			Sp. conductivity (µmhos/cm)		
(m)	Post-mon	Winter	Summer	Post-mon	Winter	Summer	Post-mon	Winter	Summer
S	10.0	Nil	Nil	92.0	112.0	116.0	117.0	212.0	312.0
1	18.0	Nil	Nil	98.0	112.0	120.0	120.0	207.0	304.0
2	30.0	Nil	Nil	108.0	112.0	120.0	125.0	205.0	304.0
3	32.0	Nil	-	114.0	110.0	-	251.0	203.0	-
4	42.0	Nil	-	120.0	110.0	-	261.0	198.0	-
5	46.0	-	-	136.0	-	-	270.0	-	-

Post-mon=Post-monsoon

Primary productivity :- The gross primary carbon production varied from 38.8 to 133.1, averaging 94.8 mgC/m²/hr while the net production ranged between 11.1 and 63.9 (average 44.3) mgC/m²/hr . Thus the expected fish yield in terms of carbon production was 96 kg/ha. This shows the medium productive state of the reservoir. The annual ratio between net and gross carbon production was 0.47. The net gross ratio of more than 0.50 is indicative of a productive water body.

Biotic communities

Plankton :- The plankton population ranged from 338 u/l in summer to 873 u/l in post-monsoon (Table 4; Fig. 1). The annual average production of 664 u/l of plankton depicted medium productivity in respect of plankton. On an average, phytoplankton formed 76.5% of the total plankton. The qualitative description of the plankton is depicted in Table 5.

Bacillariophyceae on an average, formed 24.5% of the total plankton population. The major pulse was observed during summer (37.5%). The common forms observed were medium, Meridion, Nodularia, Cymbella, Caloneis and Tabellaria.

Chlorophyceae constituted 24.6% of the total plankton was mainly represented by Scenedesmus, Pediastrum, Botryococcus and Rhizoclonium. Maximum percentage of this groups was recorded in summer (35.0%, Table 4). The percentage composition of myxophyceae fluctuated from 12.5% in summer to

38.2% in post-monsoon. Microcystis followed Oscillatoria, Spirulina and Nostoc were the dominant flora observed. Zooplankton were mainly dominated by rotifers (Notholca, Keratella, Brachionus, Asplanchna) and formed 13.1% of the total plankton. Copepods (Diaptomus, Cyclops) constituted 7.3% of the total plankton.

Abundance of pollution indicator species such as Pediastrum under chlorophyceae, Cymbella, Fragillaria under bacillariophyceae and Oscillatoira, Nostoc under myxophyceae indicated eutrophic tendency of the water body.

Table : 5 Composition of Plankton in Badkhal Reservoir.

Period	u/l	% of different groups			
		Chlorophyceae	Myxophceae	Bacillariophyceae	Rotifers
Sep-Oct,96	873	11.8	38.2	14.5	19.7
Dec-Jan.	672	27.1	31.4	21.4	7.2
May,97	448	35.0	12.5	37.5	12.5
Average	664	24.6	27.4	24.5	13.1

Table : 6 List of Plankton in Badkhal Reservoir.

Bacillariophyceae	*Nedium, Nodularia, Meridon, Tabellaria, Synedra, Caloneis, Cymbella, Melosira, Diatoma, Frustulia, Eunotia, Gomphonema,Navicula, Fragilaria*
Chlorophyceae	*Scenedesmus, Rhizoclonium, Cosmarium, Botryococcus, Pediastrum*
Myxophyceae	*Microcystis, Nostoc, Oscillatoria, Phacus, Spirulina, Phormidium*
Rotifera	*Notholca, Keratell, Brachionus,Asplanchna*
Cladocera	*Moina*
Copepoda	*Cylops, Diaptomus,nauplii*

Periphyton :- Periphytic communities were dominated by bacillariophyceae both qualitatively and quantitatively (78.5%). Periphyton population ranged from 1358 to 1843 (1584) u/cm^2 (Table 5). Myxophyceae formed 13.5% followed by chlorophyceae (7.9%). Diatoma represented by Neidium, Tabellaria, Caloneis, Nodularia, Cymbella, Nitzschia, Gomphonema, Diatoma, Synedra, Navicula, Frustulia, Meridion, Cocconeis. Chlorophyceae was comprised of Characium and myxophyceae flora of Oscillatoria and Schizothorix.

Table:7 Composition of Periphyton in Badkhal Reservoir.

Period	u/cm^2	% of different groups		
		Chlorophyceae	Myxophyceae	Bacillariophyceae
Sept-Oct,96	1358	7.1	7.1	85.8
Dec-Jan	1843	10.5	21.0	68.5
May,97	1552	6.2	12.5	81.3
Average	1584	7.9	13.5	78.5

Macrobenthos :- The standing crop of bottom macrofauna was estimated as 250 u/m² in post-monsoon, 300 u/m² in summer and 450 u/m² in winter, Table 8. On an average, the standing crop was estimated as 334 u/m2. Chironomids dominated the fauna (74.8%), followed by molluscs (15.0%) and Chaoborus (10.2%). Maximum concentration of benthos were recorded in winter season.

Table:8-Composition of Benthos in Badkhal Reservoir.

Species	Summer		Post-monsoon		Winter		Average	
	u/m²	mg/m²	u/m²	mg/m²	u/m²	mg/m²	u/m²	mg/m²
Molluscs	-	-	150	neg.	-	-	50	neg.
Chaoborus	-	-	-		100	0.26	34	0.09
Chironomids	300	0.40	100	0.26	350	0.42	250	0.36
Total	300	0.40	250	0.26	450	0.68	334	0.45

Macrophytes :- Aquatic weeds ranged from 1100 g in summer to 1200 g during post-monsoon while in winter showing an average 1.13 kg/m2 wet wt (Table 9). This indicated profuse growth of a variety of macrophytes among them the dominant forms were Hydrilla, Vallisneria, Potamogeton, Marsilea, Nelumboo and Thypa. Hydrilla forms 80% of the submerged weeds of the reservoir. Thypa and Ipomoea are restricted to the marginal area. Nelumbo penetrated the shallow areas of the water body.

Table:9- Composition of Macrovegetation in Badkhal Reservoir.

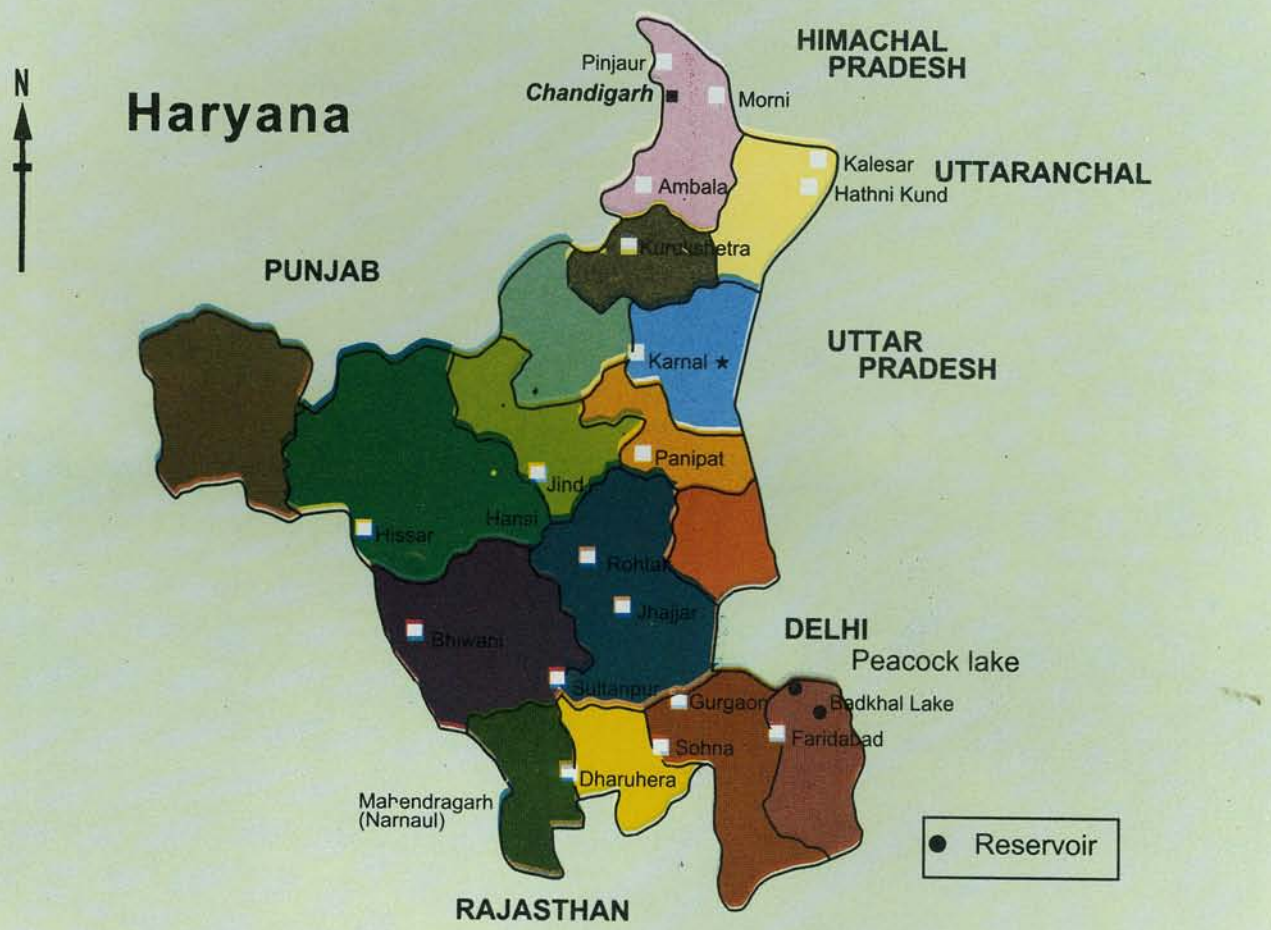
Season	Wet wt. (g/m²)	Dry wt.
Summer	1100	150
Post-monsoon	1100	60
Winter	1200	100
Average	1133	103

3.4 Fisheries

The reservoir was stocked with 6.0 lakh fingerlings of Indian major carps and common carp by the contractor in the year 1994-95 and 2.0 lakh fingerlings were stocked in 1995-96.

A variety of fisheries exists in the ecosystem which mainly includes C. catla, L. rohita, C. mrigala, C. carpio, C. idella, W. attu and Channa spp. The profuse growth of aquatic weeds shows that the herbivorus fishes are either absent or not present in adequate number in the lake. Further, the intensity of stocking is also not reflected in the fish yield as is reported probably due to macrophyte infestation which needs to be eradicated. Data on commercial fishing not available as the department of fisheries, Haryana has no direct control over the fisheries of the reservoir. The total management of the lake including the auction of the reservoir for fishing is being managed by the Department of Tourism. The fishing rights were auctioned for a period from 1.4.94 to 31.3.97 to a single contractor for Rs. 4.16 lakh. The contractor is expected to manage stocking, rearing and fishing himself.

As there is no exclusive fishermen village, the fishing parties engaged by the contractor are mostly from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UTTAR PRADESH
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Rohtak
Jhajjar
Bhiwani
DELHI
Peacock lake
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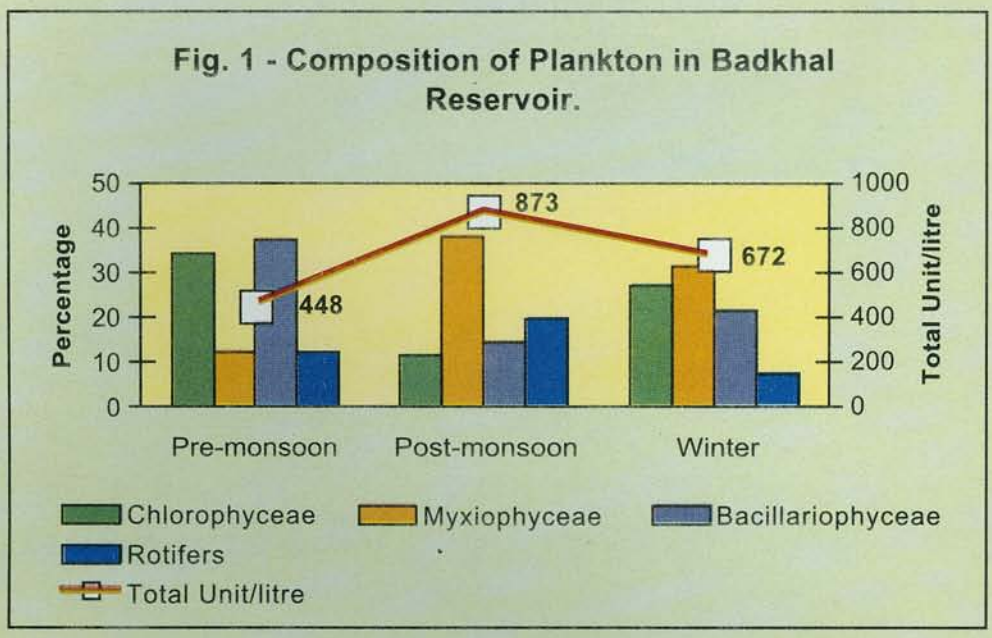
Fig. 1 - Composition of Plankton in Badkhal Reservoir.
Percentage
Total Unit/litre
50
40
30
20
10
0
1000
800
600
400
200
0
873
672
448
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Myxiophyceae
Bacillariophyceae
Rotifers
Total Unit/litre

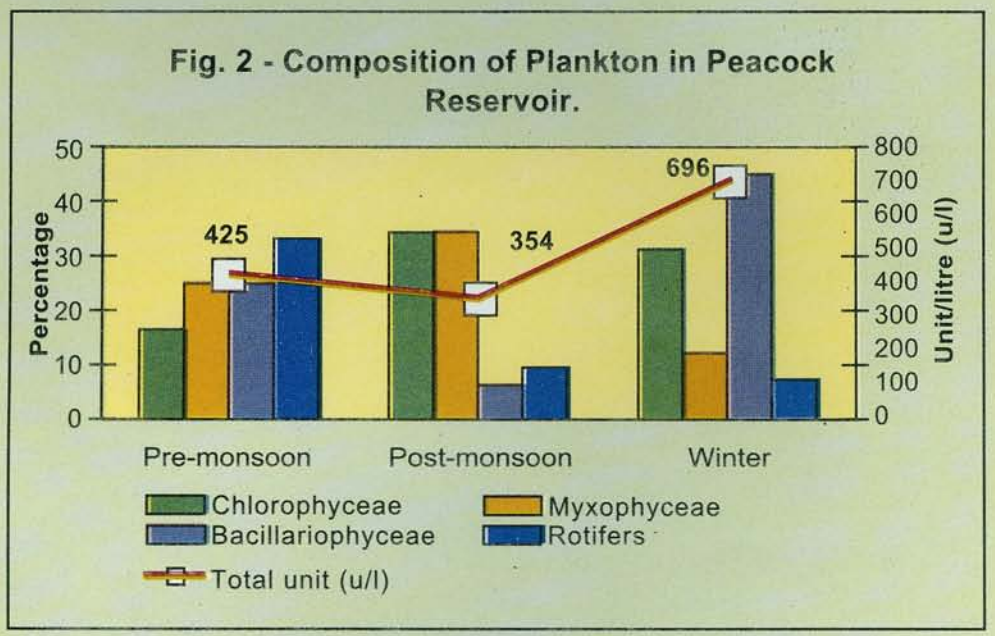
Fig. 2 - Composition of Plankton in Peacock Reservoir.
Percentage
Unit/litre (u/l)
50
40
30
20
10
0
800
700
600
500
400
300
200
100
0
696
425
354
Pre-monsoon
Post-monsoon
Winter
Chlorophyceae
Myxophyceae
Bacillariophyceae
Rotifers
Total unit (u/l)

A View of Bhadkhal Reservoir

A View of Peacock Reservoir

other states. Fishermen use only small nylon gill-nets. However, they often have the fishing problem due to infestation of aquatic weeds. Drag-nets are also used occasionally in the marginal areas for fishing particularly the fresh water prawns.

3.5 Management guidelines

Stocking policy hitherto being adopted is confined to the release of Indian major carps fingerlings without paying adequate attention to the levels or ratios of the species based on biogenic capacity of the ecosystem. The natural recruitment of major carps is either absent or poor due to non-availability of suitable breeding grounds in the lotic zone of the reservoir or on account of inadequate water flow at the desired time of spawning. The reservoir therefore requires a judicious approach with regards to stocking. Taking annual average growth rate of 0.5 kg for each of the species of carps stocked and giving an allowance of 40% due to predation, the stocking rate will be 230 numbers per hectare. The widespread planting of fingerlings of Indian major carps on an arbitrary basis by the contractor has, however, proved to be highly remunerative for such small and shallow reservoir wherein the reduction of water level pave the way far complete harvesting. Thus, it depicts direct correlation between the stocking rate and the catch from such small water bodies.

The rapid growth of macrovegetation and sedentary algae indicate a high primary production as also confirmed by the primary productivity studies. Gross production being 94.8 mgC/m2/hr. The eutrophic nature of the reservoir was evident from carbon values and increasing growth of macrophytes. In the absence of adequate number of herbivorus fishes in reservoir, the energy available from macrophytes is not transferred directly to high trophic levels. This emphasise the need for stocking of suitable firsh preferably C. idella to utilize this vacant niches. Eradication of weeds by implementing the biological control would help in increasing the efficiency of gears leading to achieve optimum utilization of available yield.

The reservoir does not have any control with regards to scientific management and exploitation of its fishery by the Department of Tourism. It is therefore suggested that lake may be put under the control of Department of Fisheries, Haryana so as to manage the reservoir fisheries by following the management norms such as limits of fishermen number, fishing gear, gear characteristics, size limits, close season and a judicious stocking.

4. PEACOCK RESERVOIR

4.1 Location and morphometry

Peacock reservoir (Surajkund) is 10 Km away from Fridabad town in the state of Haryana. It is situated in the 77° 30'E and 28° 45' N. Monsoon rains are the main source of water. The reservoir is surrounded by hills of Aravali ranges. The main purpose of its construction was to check soil erosion .The reservoir fisheries of peacock and the other management aspects of this reservoir rest with Tourism Department of Haryana. Location map of the reservoir is illustrated in Fig.1. Tourism Department of Haryana has devel-

oped the reservoir mainly for attracting tourists. The reservoir has water spread area of 10.86 ha at FRL. The other salient features of morphometry are given in table 10 .

Table :10 Location and morphometric features of Peacock reservoir.

Parameters	Peacock reservoir
Latitude N	28° 45'
Longitude E	77° 30'
Year of construction	-
Length	265.2 m
Width	6.0 m
Top reservoir level	222.4 m
Full Tank Level	220.3 m
Tank HFL	221.2 m
Creast Level (outlet)	218.5
Capacity at FSL	20 ha m
Catchment area	11.4 km^2
Average bed level of pond	215.5

4.2 Meteorological and Hydrographical observations

The silted bed level is 212.7 m while the top of water level in the reservoir is 217.0 m. The average depth of water is 4.26 m.

4.3 Limnology and productivity

Physic-chemical characteristics of soil :- Bottom soil of reservoir was sandy in texture and was alkaline in reaction during post-monsoon while it was slightly acidic in nature during pre-monsoon (Table 11). Organic carbon was low, ranging from 0.38 in post-monsoon to 0.65 in pre-monsoon. Thus, the organic carbon was poor than those reported from productive reservoirs (0.5 to 2.5%) which may be due to lesser input of allochthonous organic matter into the reservoir. The energy stored in the reservoir is thus limited and only through solar radiation and autochthonus source. Available phosphorus(5.7 to 6.8 mg/ 100g) was above the productive mark.

Table:11 Physico-chemical characteristics of Soil of Peacock Reservoir.

Parameters	Pre-monsoon	Post-monsoon
Sand (%)	42.30	90.00
Silt (%)	25.80	4.00
Clay (%)	31.70	6.00
pH	6.80	7.90
Organic carbon (%)	0.65	0.38
Free $CaCO_3$ (%)	0.73	2.75
Available phosphorus (mg/100g)	5.70	6.80
Available nitrogen (mg/100g)	63.70	14.00
Sp. conductivity (µmhos/cm)	382.0	-

Physico-chemical characteristics of water :- Water temperature of reservoir varied between 16.0 in winter to 33°C in post-monsoon and is supposed to be good for aquaculture practices. Hydrogen-ion-concentration ranged from 8.2 to 8.5. The minor fluctuations in pH clearly indicates the strong buffering capacity of the reservoir. Low values of transparency were recorded in summer (19.0 cm) and the high values were in winter (45.0 cm). High wind velocity in summer might have resulted in low transparency. Dissolved oxygen fluctuated from 4.4 to 9.6 ppm. The minimum values were recorded in winter and summer respectively (Table 12). Absence of free carbon dioxide in winter and summer is another indicator of suitability of water for fish production. It appeared in post-monsoon months (10.0 ppm). The seasonal variation in alkalinity was quite prominent with minimum values (160.0 ppm) in post-monsoon and maximum values (240.0 ppm) in summer months (Table 12). The total alkalinity thus was conducive to high fish productivity.

Calcium concentration of the reservoir varied from 19.24 to 32.04 ppm and reflected the productive nature of water body. Magnesium content was also high varying from 23.68 to 33.56 ppm (Table 12). Total hardness fluctuated from 156.0 to 184.0 ppm. Chloride ranged between 16.18 and 133.4 ppm. The values of dissolved organic matter ranged from 8.2 to 9.0 ppm indicating high content of dissolved organic matter vis-à-vis high productive state of the reservoir. Specific conductivity fluctuated from 667.0 to 905.0 µmhos/cm. High values of specific conductivity supported eutrophic character of the reservoir. These hydrological parameters clearly suggest the high productive potential of Peacock reservoir.

Table:12 Physico-chemical characteristics of surface water of Peacock Reservoir.

Parameters	Ranges	Average
Water temperature (°C)	16.0-33.0	24.7
Transparency(cm)	19.0-45.0	29.7
pH	8.2-8.5	8.4
Dissolved oxygen (ppm)	4.4-9.6	6.4
Free CO_2 (ppm)	Nil-10.0	3.3
HCO_3 (ppm)	160.0-240.0	206.7
Dissolved organic matter(ppm)	8.2-9.0	8.5
Hardness (ppm)	156.0184.0	168.0
Calcium (ppm)	19.24-32.04	25.1
Magnesium (ppm)	23.68-33.56	28.6
Chloride (ppm)	16.18-133.4	86.8
Sp. conductivity (µmhos/cm)	667.0-905.0	764.3

Thermal and chemical stratification :- Depth-wise observations of water temperature indicated the presence of thermal stratification between the surface water and 1 m depth with the drop of temperature @ 1.0°C from 33°C to 32°C in the post-monsoon period (Table 13). Water bodies which stratify thermally are known to be productive. Chemical stratification in respect of dissolved oxygen, alkalinity, specific conductivity (Table 13) was also discernible.

Table:13 Depth profile in Peacock Reservoir.

Depth	Water Temperature (°C)			pH			D.O (ppm)		
(m)	Post-mon	Winter	summer	Post-mon	Winter	summer	Post-mon	Winter	Summer
S	33.0	16.0	29.0	8.54	8.32	8.24	5.76	4.4	9.60
1	32.0		29.0	8.37		8.28	5.44		8.32
2	31.8		-	8.32		-	4.96		-
3	31.8		-	8.19		-	4.00		-

Depth	Free CO_2 (ppm)			Total alkalinity (ppm)			Sp.conductivity (µmhos/cm)		
(m)	Post-mon	Winter	summer	Post-mon	Winter	summer	Post-mon	Winter	Summer
S	10.0	Nil	Nil	160	220	240	721	667	908
1	10	-	Nil	164		250	716		742
2	12	-	-	170		-	718		-
3	12	-	-	174		-	698		-

Biotic communities

Plankton :- Plankton population of the reservoir ranged from 354 u/l in post-monsoon to 696 u/l in winter (Table 14 ; Fig. 2). The annual average production (492 u/l) was mainly dominated by phytoplankton (76.6%). Among phytoplanketrs, chlorophyceae out numbered bacillariophyceae and myxophyceae. Planktonic composition in respect of green algae was in post-monsoon (34.4%) whereas its minimum concentration was in summer months. Green algae were mainly comprised of *Arthrodesmus, Bottryococcus, Characiopsis* etc. The list of plankton is presented in Table 15.

Bcillariophyceae constiuted 25.4% of the total plankton and was mainly represented by *Diatoma, Gyrisigma, Melosira, Meridion, Cyclotella* and *Cymbella*. Maximum percentage of diatoms were observed in winter (44.8%) where as minimum was in post-monsoon (6.2%). Myxophyceae contributed 23.8% in total plankton and were represented by *Spirulina, Oscillatoria, Phormidium, Microcystis* and *Nostoc*. They had maximum percentage during post-monsoon. Among zooplankton, rotifers (*Brachionus, Keratella, Colurella*) formed 16.5% of plankton foloowed by copepods (6.8%).

Table:14 Composition of Plankton in Peacock Reservoir.

Period	u/l	% of different groups			
		Chlorophyceae	Myxophyceae	Bcillariophyceae	Rotifers
Sep-Oct,96	354	34.4	34.4	6.2	9.4
Dec-Jan.	696	31.0	12.1	44.8	6.9
May,97	425	16.7	25.0	25.0	33.3
Average	492	27.4	23.8	25.4	16.5

Table:15 List of Plankton of Peacock Reservoir.

Bcillariophyceae	*-Diatoma, Neidium, Nitzschia, Gyrosigma, Melosira, Cymbella, Meridion, Cyclotella, Frustulia.*
Chlorophyceae	*-Arthrodesmus, Boyrycoccus, Chlorococcum, Schroederia, Chraciopsis, Characium, Closteridium, Rhizoclonium, Pachycladon, Pediastrum, Closteriopsis.*
Myxophyceae	*-Microcystis, Nostoc, Spirulina, Oscillatoria, Phormidium.*
Protoza	*-Actinophyrs.*
Rotifera	*-Brachionus, Keratella, Colurella.*
Cladocera	*-Daphnia.*
Copepoda	*-Diaptomus, Cyclops, nauplii.*

Periphyton :- Periphyton population ranged between 1261 u/cm² in post-monsoon to 1455 u/cm² in summer. On an average it was encountered as 1358 u/cm² (Table16). Bacillariophyceae (68.9%) dominated over myxophyceae (19.1%) and chlorophyceae (11.9%). Bacillariophyceae was rich both qualitatively and quantitatively and was represented by *Neidium, Frustulia, Meridion, Caloneis, Cymbella, Diatoma, Tabellaria, Nitaschia* and *Gomphonema. Characium* represented chlorophyceae while *Oscillatoria* and *Schizothorix* represented myxophyceae.

Table:16 Composition of Periphyton in Peacock Reservoir.

Period	u/cm²	% of different groups		
		Chlorophyceae	Myxophyceae	Bcillariophyceae
Sep-Oct,96	1261	15.4	15.4	79.2
Dec-Jan.	1358	7.1	28.6	64.3
May,97	1455	13.3	13.3	73.4
Average	1358	11.9	19.1	68.9

Macrobenthos :- Macrobenthos of Peacock reservoir were dominated by chironomids (60.9%; Table 17). The average abundance of macrobenthos was of moderate level (384 u/m²). It ranged from 200 u/m² in post-monsoon to 650 u/m² in winter. *Chaoborus* formed 34.8% of the standing crop followed by molluscs (4.2%). The poor abundance of macrobenthos among biotic communities may be due to limited concentration of organic matter in the soil.

Table:17 Composition of Benthos in Peacock Reservoir.

Species	Summer		Post-monsoon		Winter		Average	
	u/m²	mg/m²	u/m²	mg/m²	u/m²	mg/m²	u/m²	mg/m²
Molluscs	-	-	50	neg	-	-	16	neg
Chaoborus	100	0.12	100	0.12	200	0.24	134	0.16
Chironomids	200	1.00	50	0.13	450	1.17	234	0.76
Total	300	1.12	200	0.25	650	1.41	384	0.92

Macrovegetation :- The reservoir is devoid of any aquatic vegetation, which could ascribed to poor concentration of organic matter in the soil

Stocking :-The lake was stocked with 2.0 lakh and 1.25 lakh of IMC fingerlings during 1994-95 and 1995-96 respectively. Thus, the stocking rate was 15046 per hectare per year.

4.4 Commercial fishing

The fishing policies for the lake are devoid of any scientific management as is evident from exploitation of the water body once in a year depending upon the expertise of fishing party engaged by the contractor. The reservoir had been auctioned for Rupees three lakh for the period from 1994-95 to 1996-97. Stocking, rearing and fishing is being managed by the contractor. The Department of Fisheries, Haryana has no control and the reservoir is totally under the management of Department of Tourism, Haryana.

In Peacock lake, the species thriving are reported to be *C. catla, L. rohita, C. mrigala, C. carpio, H. fossilis* and *P. sarana*. The fishery of the reservoir is totally dependent on the stocked species of culturable variety. Fishing in the reservoir is carried with the help of gill-nets as well as drag-nets. Complete harvesting of the reservoir invariably is being attempted with the help of drag-nets at low water level during summer. The fish landing data was, however, not available for the study.

4.5 Recommendations

Peacock 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. There is, thus, a direct co-relation between stocking rate and catch per unit effort. The ecological investigations of Peacock reservoir has revealed the need for improvement in management strategy basing on the biogenic productivity, the trophic structure and functions of the reservoir.

Fish culture in Peacock reservoir, hitherto being practiced 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. Attention has also not been paid to the aspect of ratios of species and number and sizes of fish seed to be introduced. Based on the productive potential of the lake, a stocking rate of 120 fingerlings per hectare may be adopted for the reservoir.

The irregular fishing in the reservoir need scientific orientation. Gill-nets of mesh bar 40,50,60 and 75 mm be used for fishing. Since the reservoir is shallow, the depth of nets need to be adjusted according to the water level. Being a small irrigation impoundment, the drastic draw down of water enables total harvesting. In order to ensure the total harvesting more units of drag-nets may be introduced.

The Deptt. of Tourism, has no control with regards to scientific management and exploitation of Peacock reservoir. It is suggested that the lake may be put under the control of Department of Fisheries, Haryana, enabling them to manage the reservoir fisheries by following the management norms such as limits of fishermen number, fishing gear, gear characteristics, size limits, close season and a judicious stocking.

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