Pen Farming in A Small River: Its Impact on Fish Production and Economic Condition of Pen Farmers

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Abstract— *Present study was conducted in the river Chota Bhagirathi in Malda district of West Bengal to assess the productivity of fish-pens and its impact on economic condition of the pen farmers. Fifteen pen farmers were selected for the study and their age ranged from 25-40 yrs. Among them 53.33% were 31-35 yrs old and 33.33% were within 36-40 yrs. Individual pen farming area varied from 3.0 ha to > 6.0 ha in the river Chota Bhagirathi. According to the size, pens were categorized into three groups: small pen (3.0-4.5 ha), medium pen (4.6-6.0 ha) and big pen (> 6.0 ha). Small pen farmers contributed 40.00%, medium pens 33.33% and big pens 26.67% of the total pen farming area in the river. The lease amount of pens varied according to pen area. Maximum fish production achieved from P1 (3281 kg/ha/year), P7 (3333 kg/ha/year), P8 (3444 kg/ha/year), P9 (3225 kg/ha/year) and P10 (3279 kg/ha/year) compared with other pens. P1 (Rs. 1,14,474 ha/year) earned highest profit and P8 (Rs. 1,06,771 ha/year) was second highest among 15 pens. Among the selected pen farmers, 73.33% were from non-fisherman community and only 26.67% from original fisherman folk.*

Keywords— Pen Farming, Age, Production, Economics.

I. INTRODUCTION

Fish farming in river means culture of fish in enclosures like cages or pens which is manageable and remain under control. Farming in pens is the most favorable solution in increasing fish production without further conversion of wetlands and mangroves into aquaculture ponds. Pens are high production systems, relatively simple and less expensive to construct but requires a large amount of working capital due to high cost of commercial feeds in sites where feeding is needed. The development and adoption of inland water pen culture has been much less dramatic than that of cage culture and at present pens are used for various aquaculture activities on a commercial basis in many countries such as the Philippines, Indonesia, Thailand, Malaysia, China and USA (Beveridge, 1984; Chua and Teng, 1977; Lam, 1982; Shang and Tisdell, 1997). In India, experiments have been carried out to raise carp seed using pen culture in oxbow lakes, swampy tanks, beels and reservoirs (Abraham, 1980; Banerjee and Pandey, 1978; Mane, 1982; Swaminathan and Singit, 1982; Yadava *et al*., 1983). In Assam, fingerlings raised in pens have shown higher rate of survivability, better growth and increasing the fish production (Chandra, 2010).

Stocking of advanced fingerlings (>100 mm) in reservoirs for achieving higher survival and fish production is an age old practice. However, the development agencies continue to stock smaller fish seed (15-40 mm) because of inadequate rearing space in land-based ponds as construction of new ponds is capital intensive. In this situation, fish culture in pens becomes desirable as the pens can be erected even by unskilled labour, and the materials required for the fabrication of pens is inexpensively and readily available in the local markets (Natarajan, 1976 and Selvaraj *et al*., 1990).

A study was undertaken in the river Chota Bhagirathi in Malda district of West Bengal to assess the productivity of fish-pens and its impact on economic condition of the pen farmers.

II. METHODOLOGY

The study was carried out through interrogation (selective questioners) of pen farmers of the river. Farming activities were monitored regularly from close quarters. The river Chota Bhagirathi is a freshwater perennial river which originates from the river Ganga at Khaskol in Malda district. Total length of the river in Malda district is 35 km (approx.) and breadth varying from 70-85 m in place to place. The maximum depth of the river during the peak monsoon is 10ft (approx.), but usually the depth varies between 6-8 ft. There were 15 numbers of fish-pens (P1-P15) were operated along the river stretch selected for the study (Plate. 1).

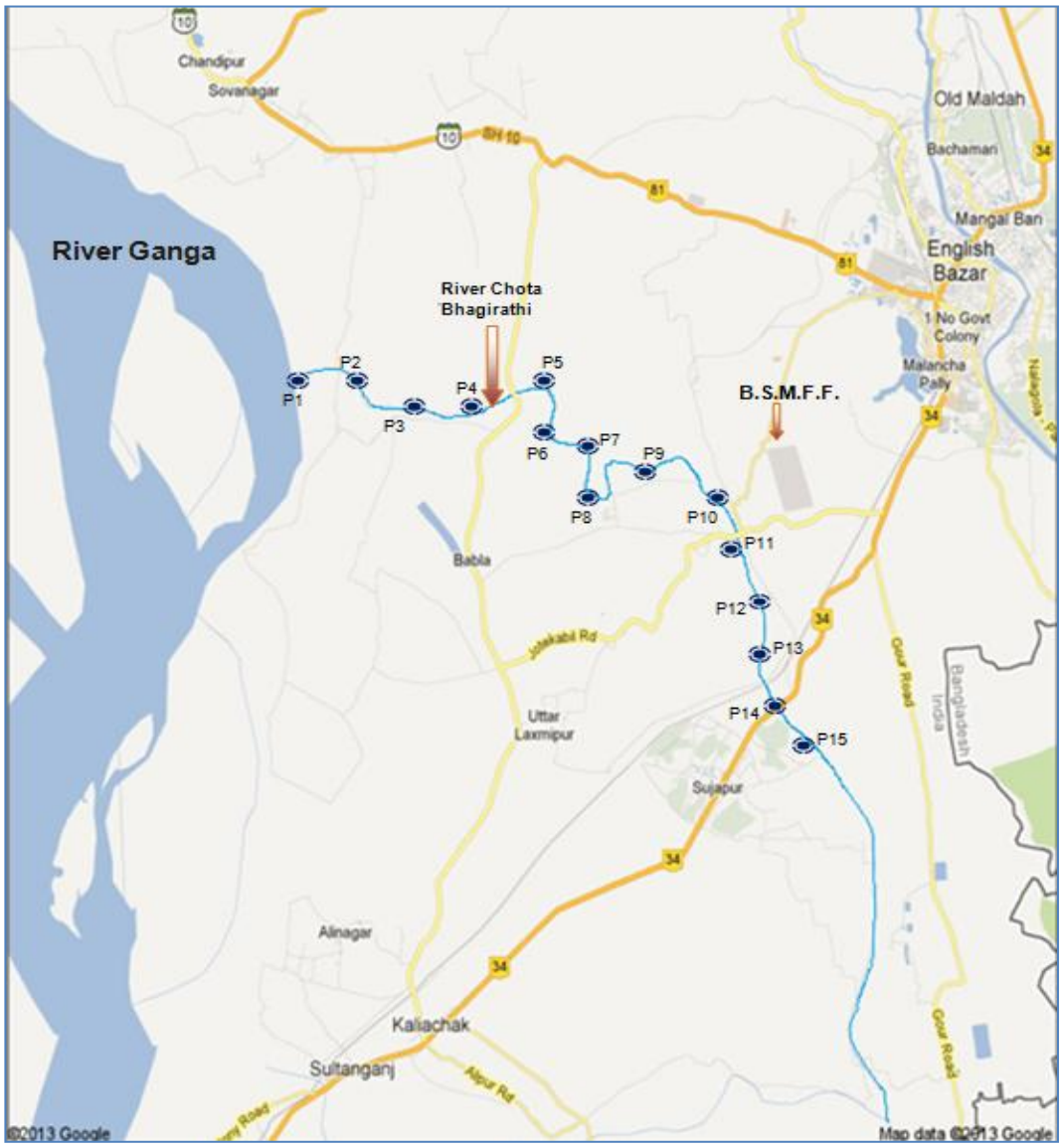

PLATE: 1. FISH PENS IN RIVER CHOTA BHAGIRATHI IN MALDA, W.B.

P1 to P15: Fish-Pens selected in river Chota Bhagirathi; B. S. M. F. F. (Barasagardighi Model Fish Farm): 24.96° N (Latitude) & 88.10° E (Longitude).

2.1 Construction of fish-pens in the river Chota Bhagirathi:

Bamboo poles, bamboo splits or bamboo slats, coconut fibre rope, coir rope, nylon ropes and polyethylene or mosquito nets etc. were common materials used for construction of a fish pen. A pen varied in size and may cover few bighas to few hectares for fish farming.

In Chota Bhagirathi, fish-pen construction is different from traditional pen farming practices. Pen farmers of this river enclosed their farming area by pen frame. Only two side of the pen were covered i.e. up side and down side of the river. One frame was placed at the upper stretch and another on the down stretch along the entire width of the river. A frame was constructed using small units of fence (locally called bana). A bana was prepared by bamboo splits and joint together with coconut fibre rope, coir rope or nylon ropes. The size of each bana (approx. 6 ft height and 8 ft in length) varied from pen to pen. Several bana(s) (15-30) were joined together to form pen frame in one side (Plate. 2) and same kind of frame was placed on another side of the river. The structural framework was prepared using 2.5 m long bamboo poles (fixed in the bottom-mud vertically along the guide rope at 1.0 m intervals) with upper & middle bamboo bracing. Pen screen (12 mesh/cm) of desire depth was lined inside the pen structure. The whole frame was supported on each side by long bamboo poles having gap of 7-8 ft between two pens (Plate. 2). Longevity of these types of pen frames varied from 1-1.5 yr.

PLATE: 2. SHOWING TWO DIFFERENT PENS AND GAPS BETWEEN THEM IN RIVER CHOTA BHAGIRATHI.

2.2 Manuring

Farmers used both organic manure (cow dung, mahua oil cake and occasionally poultry excreta) and inorganic fertilizers **(**urea, SSP, lime etc) at different doses to accelerate plankton production and maintain good fish health (Table. 1).

TABLE 1
MANURES AND FERTILIZERS USED BY PEN FARMERS

Zones	Pens	Organic Manures		Inorganic Fertilizers				Total manure & fertilizer used in pen (Kg/ha/yr)	Average manure & fertilizer used in pens (Kg/ha/yr)
		Cow dung (Kg/ha/yr)	Mahua oil cake (Kg/ha/ yr)	Urea (Kg/ha/yr)	SSP (Kg/ha/yr)	Lime (Kg/ha/yr)	Salt (Kg/ha/yr)		
Z-I	P1	2500	312	750	1875	250	469	6156	3724
	P2	-	-	525	750	300	-	1575	
	P3	2295	328	-	-	400	417	3440	
Z-II	P4	-	-	-	-	600	-	600	3202
	P5	1200	-	480	720	280	-	2680	
	P6	2500	-	1200	1800	825	-	6325	
Z-III	P7	2000	333	1200	1800	600	333	6266	5314
	P8	1778	-	833	1533	533	444	5121	
	P9	1613	-	725	1089	774	355	4556	
Z-IV	P10	1639	656	1180	1967	619	328	6389	2230
	P11	-	-	-	-	-	-	-	
	P12	-	-	-	-	300	-	300	
Z-V	P13	1334	-	-	-	600	418	2352	2556
	P14	-	-	-	-	923	-	923	
	P15	2000	328	492	984	590	-	4394	

2.3 Release of fish seed

Desired cultivable fishes *viz.* Indian Major Carps, minor carp, exotic carp, big-head and common carp were stocked in pen. Fingerlings (8-12 cm) of cultivable fishes (Table. 3) were generally stocked @ 15,000-40,000 fingerlings/ha.

2.4 Feeding

The fishes were fed either in the morning or in the afternoon. A mixture of grain dust (corn, wheat, soya bean and sorghum) and EPIC (feed of W. B. Dairy Poultry Dev. Corp.) were generally used as feed of the fishes. Mustard oil cake and rice bran were also given as supplementary feed in all fish-pens (Table. 2). Feed were generally provided to fishes by hand feeding method. Wooden and tin boats were used for broadcasting of feed in fish-pens.

TABLE 2
APPLICATION OF DIFFERENT TYPES OF FEEDS IN PENS

Zones	Pens	Application of Different Types of Feeds					Total feed used in each pen (Kg/ha/yr)	Average Feed used in pens (Kg/ha/yr)
		Grain dust (Kg/ha/yr)	EPIC (Kg/ha/yr)	Mustard oil cake (Kg/ha/yr)	Maize Bran (Kg/ha/yr)	Rice Bran (Kg/ha/yr)		
Z-I	P1	3750	-	248	376	-	4374	4294
	P2	1560	-	1820	-	-	3380	
	P3	3410	852	867	-	-	5129	
Z-II	P4	1667	-	1667	-	-	3334	2667
	P5	-	-	1456	-	-	1456	
	P6	1950	-	1260	-	-	3210	
Z-III	P7	693	607	2600	-	-	3900	4539
	P8	3044	-	1387	222	-	4653	
	P9	2355	-	2710	-	-	5065	
Z-IV	P10	682	597	2626	-	-	3905	3412
	P11	1666	-	1132	-	-	2798	
	P12	3233	-	300	-	-	3533	
Z-V	P13	1666	-	1668	-	-	3334	2784
	P14	2524	-	600	-	369	3493	
	P15	640	-	885	-	-	1525	

2.5 Harvesting

After 3-4 months of culture, IMC of 100-120 gm and exotic carp of 300-350 gm were harvested partially by using gill nets, drag nets, cast nets and scoop nets. After harvesting, the fish stock was replenished with desirable species of fish seed and cultured for a period of another 3-4 months (Table. 3). The pen farming was thus a continuous process and therefore, 3-4 batches of fish were cultured in a year. The harvested fish were generally marketed either directly by pen owner or through middleman.

TABLE 3
STOCKING, CULTURE AND PRODUCTION OF FISH IN FISH-PENS

Zones	Pens	Species stocked	Rate of Stocking (kg/ha/yr)	Size of fish stocked	Type of culture (Poly/ composite/ mono culture)	Marketable size	Culture period	Production Kg/ha/yr (Approx.)
Z-I	P1	IMC, Exotic carp, Bata, Bighead	562	9-10cm	Composite	IMC, Bata: 150 gm Others: 400gm	4 month	3281
	P2	IMC, Exotic carps, American Rohu	500	7- 8 cm	Composite	IMC : 140 gm Others: 500gm	4 month	2500
	P3	IMC, Bighead, Exotic carps	410	9-10 cm	Composite	IMC : 200 gm Others: 400gm	4 month	2167
Z-II	P4	IMC, Bighead, Minor carps	555	6 - 8 cm	Composite	IMC : 150 gm Others: 350gm	3 month	2500
	P5	IMC, Bighead, Exotic carps, Bata	640	8 - 9 cm	Composite	IMC, Bata: 150 gm Others: 350gm	4 month	2500
	P6	IMC, Exotic carps, Bata	500	7- 8 cm	Composite	IMC, Bata: 150 gm Others: 400gm	4 month	2875
Z-III	P7	IMC, Minor carps, Bighead	500	9-10 cm	Composite	IMC, Bata:150 gm Others: 450gm	3 month	3333
	P8	IMC, Exotic carps, Bata, American Rohu	622	10-11 cm	Composite	IMC, Bata:150 gm Others: 400gm	4 month	3444
	P9	IMC, Exotic carps, American Rohu	645	8 cm	Composite	IMC : 150 gm Others: 400gm	4 month	3225
Z-IV	P10	IMC, Exotic carps, Bighead	492	7-8 cm	Composite	IMC :150 gm Others: 450gm	3 month	3279
	P11	IMC, Exotic carps, American Rohu	377	9-10 cm	Composite	IMC :100 gm Others: 400gm	3 month	1792
	P12	IMC, Exotic carps	333	7-8 cm	Composite	IMC : 150 gm Others: 350gm	3 month	1667
Z-V	P13	IMC, Exotic carps, Bata, American Rohu	444	7-8 cm	Composite	IMC, Bata:150 gm Others: 300gm	3 month	1955
	P14	IMC, Exotic carps, American Rohu	308	7-8 cm	Composite	IMC :150 gm Others: 450gm	4 month	1769
	P15	IMC, Exotic carps, Bata, Bighead	410	9-10 cm	Composite	IMC, Bata: 100gm Others: 400gm	4 month	1967

III. RESULTS

The results were obtained through interviews and interrogation of pen farmers. The major findings of the study are as follows:

3.1 General information of pen farmers

Fifteen pen farmers were selected for the study and their age ranged from 25-40 yrs. Among them 53.33% of the farmers were 31-35 yrs old and 33.33% were within 36-40 yrs. Farmers having the age group of 25-30 yrs were only 6.67% and > 40 yrs were also exhibited the same percentage. From the above observation, it was revealed that pen farming venture in the river Chota Bhagirathi was accepted by the farmers aged between 31-35 yrs and second highest age group was between 36-40 yrs.

3.2 Gender

Gender of the pen farmers is an important factor for the study. It was found that all the pen farmers were male and no female entrepreneur was interested in pen farming.

3.3 Occupational status

Rural people are engaged in various activities for earning their livelihood. The data regarding occupational status indicated that fish farming is an occupation and performed fishermen not only by-birth. Among the selected pen farmers, 73.33% were from non-fisherman community and only 26.67% from original fisherman folk (Table. 5).

3.4 Ownership of water body

About 46.67% farmers of this study reported existence of their own pond but insufficient water compelled them to run to Chota Bhagirathi for pen farming. All of them invested a hefty amount of money for getting lease of the selected pen farming area.

3.5 Area of pens

Individual pen farming area varied from 3.0 ha to > 6.0 ha in the river Chota Bhagirathi. According to the size of the area, pens were categorized into three groups: small pen (3.0-4.5 ha), medium pen (4.6-6.0 ha) and big pen (> 6.0 ha). Small pens contributed 40.00%, medium pens 33.33% and big pens 26.67% of the total pen farming area in the river.

3.6 Lease amount of pen

The lease amount of pens varied according to pen area. The small pens (3.0-4.5 ha) were leased @ Rs. 1.0 lakh/yr, in medium pens (4.6-6.0 ha) the rate was Rs.1.5 lakh/yr and in big pens (>6.0 ha) the rate varied from Rs. 1.5-1.7 lakh/yr.

3.7 Manpower used in pens

Utilization of manpower (No/ha/yr) varied in all pens. Maximum man power was used in P8 and minimum in P5. Maximum manpower was used in P7 to P9 and it was due to clearance of aquatic weed from pen area. In P10, maximum manpower was also used for clearance of aquatic weed.

3.8 Production of fish in pens

Fish production varied in all pens (Table. 3). It was observed that maximum fish production achieved from P1, P7, P8, P9 and P10 compared with other pens and also found that fish production in pens (P11-P15) constructed at the lower stretch of the river was poor.

3.9 Annual profit

From the graphical representation it was observed that P1 earned highest profit and P8 was second highest among 15 pens (Table. 4). From the graphical representation it was observed that poor profit was achieved in P3, P11, P12, P14 and P15. When the profit of P1 was compared with P3, it was observed that P3 achieved 115.55% less profit than P1. Similarly 117.64%, 139.48%, 133.52%, 128.49% less profit was recorded in P11, P12, P14 and P15 respectively than P1.

TABLE 4
PROFIT GENERATED FROM FISH-PENS

Zones	Pens	Marketing (Through middle man/ direct / both)	Profit (Rs/ha/yr)(approx.)
Z-I	P1	Both	1,14,474
	P2	Through middle man	72,175
	P3	Through middle man	53,106
Z-II	P4	Through middle man	71,800
	P5	Both	64,948
	P6	Both	82,662
Z-III	P7	Through middle man	77,280
	P8	Through middle man	1,06,771
	P9	Both	70,730
Z-IV	P10	Through middle man	68,424
	P11	Through middle man	52,596
	P12	Through middle man	47,800
Z-V	P13	Both	66,543
	P14	Both	49,021
	P15	Through middle man	50,100

Highest level of profit was achieved from P1, second highest profit was obtained from P8 but P12 exhibited lowest annual profit among all fish-pens. Though it was revealed that financial profit of all pens in five zones didn't exhibit any significant relationship among them (Table. 2).

IV. DISCUSSION

Chota Bhagirathi, a perennial river with moderate water flow, having a depth of 6-8 ft is an ideal river for fish-pen farming. According to Yap *et al.,* (2007) water depth less than 1.5 m is not considered ideal for fish-pen farming. People from different background (mainly agriculture and horticulture) having sound financial support are engaged in this fish-pen farming venture. Out of 15 selected farmers 73.33% were from non fisherman community and only 26.67% were from fisherman folk (Table. 5). So fish-pen farming is performed not only fisherman by-birth. It was observed that traditional fishermen (fisherman by-birth) either were not financially sound or young generations of this community were not interested in their traditional occupation. More than 50% of pen farmers didn't have any fish pond of their own, only 46.66% possessed own ponds of about 0.2 ha. Lack of sufficient water for fish farming was a major constraint and economically solvent fish farmers accepted the fish-pen farming venture paying hefty amount of money for lease.

TABLE: 5
OCCUPATIONAL STATUS OF PEN FARMERS (BY-BIRTH / BY-PROFESSION) (N=15)

Sl. No.	Occupation	Frequency	Percentage (%)
1	Fisherman (by-profession)	11	73.33
2	Fisherman (by-birth)	4	26.67

The local fishermen Co-operative society selected an area of the river for fish-pen farming, allotted to fish farmers and collected lease amount which varied according to the pen area. The lease amount varied from Rs. 1 lakh/yr (for small pens) to 1.5-1.7 lakh/yr (for big pens). Pen farmers invested lakhs of rupees for fish farming expecting good return but it was observed that not all farmers harvested good return from their pens.

Among 15 selected pen farmers, it was observed that 53.33% were within the age group of 31-35 yrs and next highest group was 36-40 yrs which contributed 33.33% of total pen farmers. Pen farmers below 30 yrs and above 40 yrs contributed only 6.67%. From the study it was observed that the age group of 31-40 yrs was interested and accepted the fish-pen farming as business venture. Below and above this age group (31-40 yrs) percentage of participation was poor (6.67%) for high risk and uncertainty of return. Also it was observed that not a single female enrolled her name in this farming business possibly due to several hazards like financial problem, labour constraints, management problem etc.

In the present study it was observed that 40% farmers selected pen area within 3.0-4.5 ha. Pen area of 4.6-6.0 ha area was selected by 33.33% farmers and 26.67% farmers selected area more than 6.0 ha. Fish-pen farming is associated with several activities like planning, finance, manpower and good management practices. Management of fish-pen farming demands some expertise and smaller water bodies are comparatively easy to manage. As fish-pen farming is associated with some structures (pen enclosure) which are generally perishable and need repair in every year, management of small areas (0.02-0.04ha) is thus desirable (Bhowmick *et al.,* 2011).

Production of fish in net enclosure depends on several factors of which stocking density is considered as prime one. Stocking density of fish varied from pen to pen but average stocking density (12,150 fingerling/ha) was half of the normal recommended stocking density (25,000-30,000/ha; Castillon, 1982 and Guerrero, 1982). From the study it was observed that fish production in pens (P11-P15) constructed at the lower stretch of the river was poor. Correlation coefficient (r) between stocking and production of fish in pens was calculated and the value (0.9002) exhibited 1% significant (Table. 6).

From the study it was observed that lease amount varied according to the area of a pen. Profit of any business depends on selling price minus cost of expenditure (P = S – E, where P = profit, S = selling price and E = expenditure). If expenditure became high, profit margin will be less. Leased amount of Rs. 1.5 to 1.7 lakh/yr for pen >6.0 ha pen area put extra burden to the farmers because of high investment cost. As it was stated by Bhowmick *et al.* (2011) that small pen areas are easy to maintain, pen area more than 6.0 ha was thus selected by 26.67% farmers only due to its higher risk factor. In the present study, it was observed that P1 (3.2 ha) and P8 (4.5 ha) exhibited highest profit and the pens were comparatively smaller in size than other pens. Correlation coefficient (r) between profit and production of fish was calculated and the value (0.9185) exhibited 1% significant (Table. 6).

The study exhibited that all the pens were not fertilized with organic manures. Owner of P2, P4, P11, P12 and P14 didn't apply any kind of organic manure in their farming system which was reflected on their low fish production. Correlation coefficient (r) between production and manuring in pens was calculated and the value (0.9321) exhibited 1% significant (Table. 6).

TABLE: 6
CORRELATION (R) AMONG SOME FISH FARMING PARAMETERS OF PEN IN THE RIVER CHOTA BHAGIRATHI (N=5)

Fish Farming Parameters	Correlation coefficient (r)
Profit and Production	0.9185^{**}
Production and Manuring	0.9321^{**}
Production and Fish Stocking	0.9002^{**}
Production and Feeding	0.7238^{NS}

Use of inorganic fertilizer also didn't follow standard recommendation in this farming system. Minimum dose of lime was 250 kg/ha/yr and maximum dose was as high as 923 kg/ha/yr which was three times more than recommended dose (200-300 kg/ha; Islam, 2010). As stated earlier about lotic nature of the Chota Bhagirathi, lime applied in upper stretch carried its effect towards the downstream of the river. Thus gradual accumulation of lime from upper to lower stretch might have caused deleterious effect on fish production and poor performance was recorded in pens (P11-P15) (Sahoo, 2012).

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